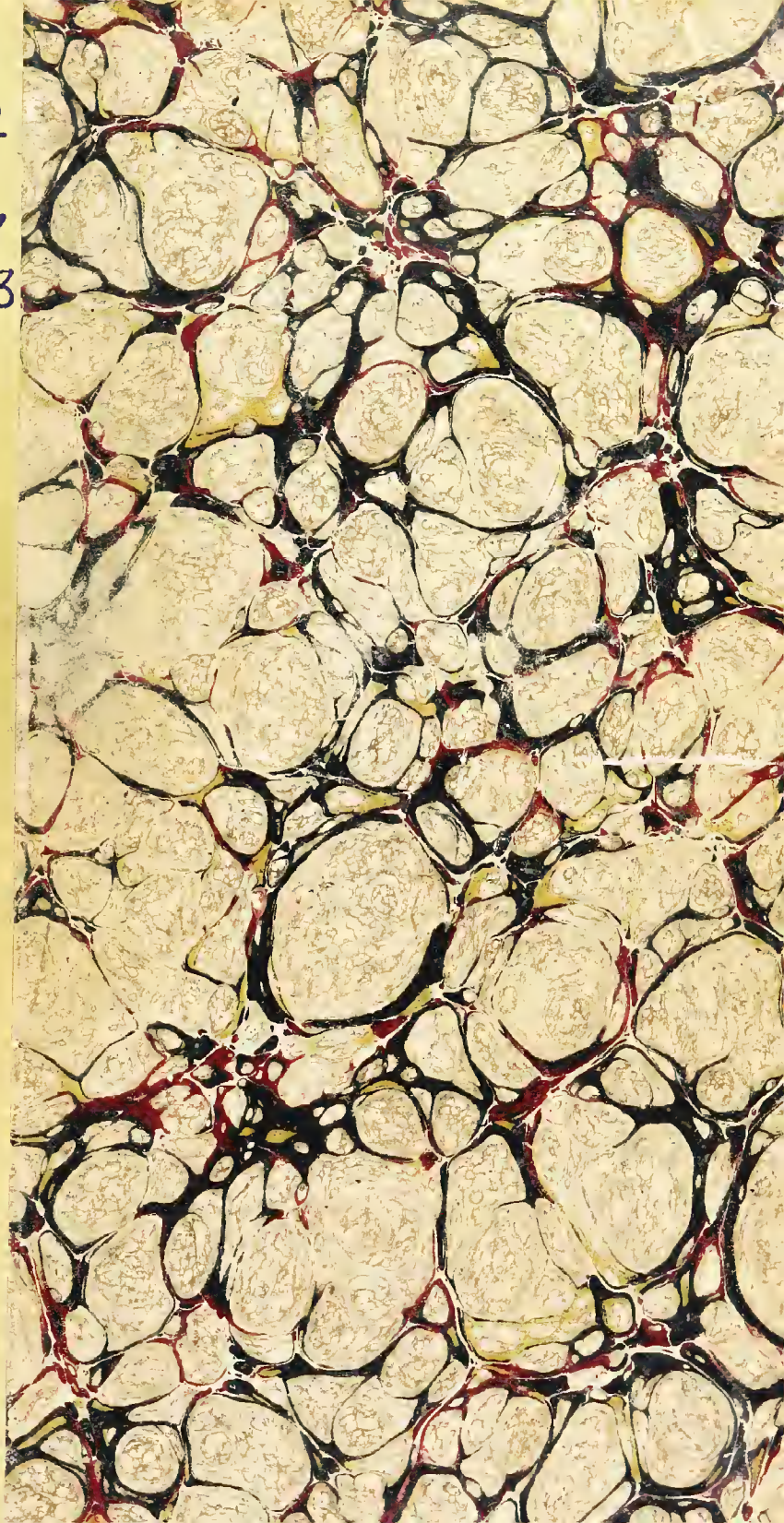


MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF

THE COUNTRY AROUND

TORQUAY.

(Explanation of Sheet 350.)

BY

W. A. E. USSHER, F.G.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.

LONDON:

PRINTED FOR HIS MAJESTY'S STATIONERY OFFICE
BY WYMAN AND SONS, LIMITED, FETTER LANE, E.C.

And to be purchased from
E. STANFORD, 12, 13, AND 14, LONG ACRE, LONDON;
JOHN MENZIES AND CO., ROSE STREET, EDINBURGH;
HODGES, FIGGIS, AND CO., 104, GRAFTON STREET, DUBLIN;
From any Agent for the sale of Ordnance Survey Maps; or through any Bookseller from the Ordnance Survey Office, Southampton.

1903.

Price Two Shillings.

LIST OF MAPS, SECTIONS, AND MEMOIRS OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES, AND MUSEUM OF PRACTICAL GEOLOGY.

J. J. H. TEALL, M.A., F.R.S., Director of the Geological Survey and Museum, Jermyn Street, London, S.W.

The Maps and Memoirs are now issued by the Ordnance Survey. They can be obtained from Agents or direct from the Ordnance Survey Office, Southampton.

Museum Catalogues, Guides, &c., are sold at the Museum, 28, Jermyn Street, London.

A Complete List of the Publications can be obtained from the Ordnance Survey Office, Southampton. Price 1*s.*

GENERAL MAP (one inch to 4 miles).

ENGLAND AND WALES.—Sheet 1 (Title); 2 (Northumberland, &c.); 3 (Index of Colours); 4 (I. of Man); 5 (Lake District); 6 (E. Yorkshire); 7 (North Wales); 8 (Central England); 9 (Eastern Counties); 10 (South Wales and N. Devon); 11 (W. of England and S.E. Wales); 12 (London Basin and Weald); 13 (Cornwall, &c.); 14 (South Coast, Torquay to I. of Wight); 15 (S. Coast, Havant to Hastings). Sheet 1, 2*s.*: sheets 2 to 15, 2*s.* 6*d.* each. *Printed in colours.*

MAPS (one-inch). Old Series.

Nos. 1 to 110 in whole sheets and quarter-sheets, hand-coloured, in two editions, Solid. Drift—except 92 NE., SE., 93 NW., SW., 97 SE., 98 NW., SW., S.E., and 101 S.E., which are published Solid only. Prices, whole sheets, 4*s.* to 8*s.* 6*d.*; quarter-sheets, 1*s.* 6*d.* to 3*s.* Large map of London and environs, Solid, 22*s.*; Drift, 30*s.* Sheet 7, Drift 18*s.* 6*d.*

MAPS (one-inch). New Series.

1 to 73. These New Series maps are identical with the Quarter Sheets of the Old Series, Nos. 91 to 110, all of which are published with Drift, excepting Sheets 29, 38, 48, 49, 51, 61, 62, 69, and 70.

	Price. Solid.	Drift.
	s. d.	*s. d.*
ISLE OF MAN Sheets 36, 45, 46, 56 and 57	8 6	8 6
123. STOKE-UPON-TRENT (Colour printed).. ..	1 6	1 6
155. ATHERSTONE	3 0	3 0
156. LEICESTER (Drift; colour printed)	3 0	1 6
187. HUNTINGDON	—	3 0
203. BEDFORD	—	3 0
231. MERTHYR TYDFIL ..	3 0	3 0
232. ABERGAVENNY (Solid, colour printed)..	1 6	3 0
248. PONTYPRIDD (Solid, colour printed)	1 6	3 0
249. NEWPORT (Mon.), PONTYPOOL, CAERPHILLY (Solid, colour printed)...	1 6	3 0
261 and 262. BRIDGEND and COAST near KENFIG, GLAMORGANSHIRE..	3 0	3 0
263. CARDIFF and WORLE, SOMERSET	3 0	3 0
267. NEWBURY	—	3 0
268. READING	3 0	3 0
282. DEVIZES	—	3 0
283. ANDOVER	—	3 0
284. BASINGSTOKE	—	3 0
298. SALISBURY (Colour printed) ..	—	1 6
299. WINCHESTER	—	3 0
300. NEW ALRESFORD	—	3 0
314. RINGWOOD (Colour printed) ..	—	1 6
315. SOUTHAMPTON	—	3 0
316. HAVANT	—	3 0
325. EXETER	—	3 0
328. DORCHESTER	—	3 0
329. BOURNEMOUTH, WIMBORNE MINSTER	3 0	3 0
330. Parts of NEW FOREST and part of ISLE OF WIGHT..	3 0	3 0
331. PORTSMOUTH and part of ISLE OF WIGHT	3 0	3 0
ISLE OF WIGHT with Mainland Sheets 330, 331, 344, 345 . ..	8 6	8 6
332. BOGNOR, SELSEA, LITTLEHAMPTON	1 6	1 6
333. WORTHING, ROTTINGDEAN ..	—	1 6
334. NEWHAVEN, EASTBOURNE ..	—	3 0
339. NEWTON ABBOT	—	3 0
340. OTTERTON	—	1 6
341. DORSET COAST, LANGTON HERRING	—	1 6
342. PORTLAND, WEYMOUTH, LULWORTH	—	3 0
343. SWANAGE, CORFE CASTLE ..	—	3 0
349. PLYMOUTH and IVYBRIDGE ..	—	3 0
350. TORQUAY	—	3 0
355. KINGSBRIDGE	—	3 0
356. START POINT	—	1 6

MAPS (SIX-INCH).

The Coal-fields and other mineral districts of the N. of England are in part published on a scale of six inches to a mile, at 4*s.* to 6*s.* each. MS. Coloured Copies of other six-inch maps, not intended for publication, are deposited for reference in the Geological Survey Office, Jermyn Street, London, and copies can be supplied at the cost of drawing and colouring the same.

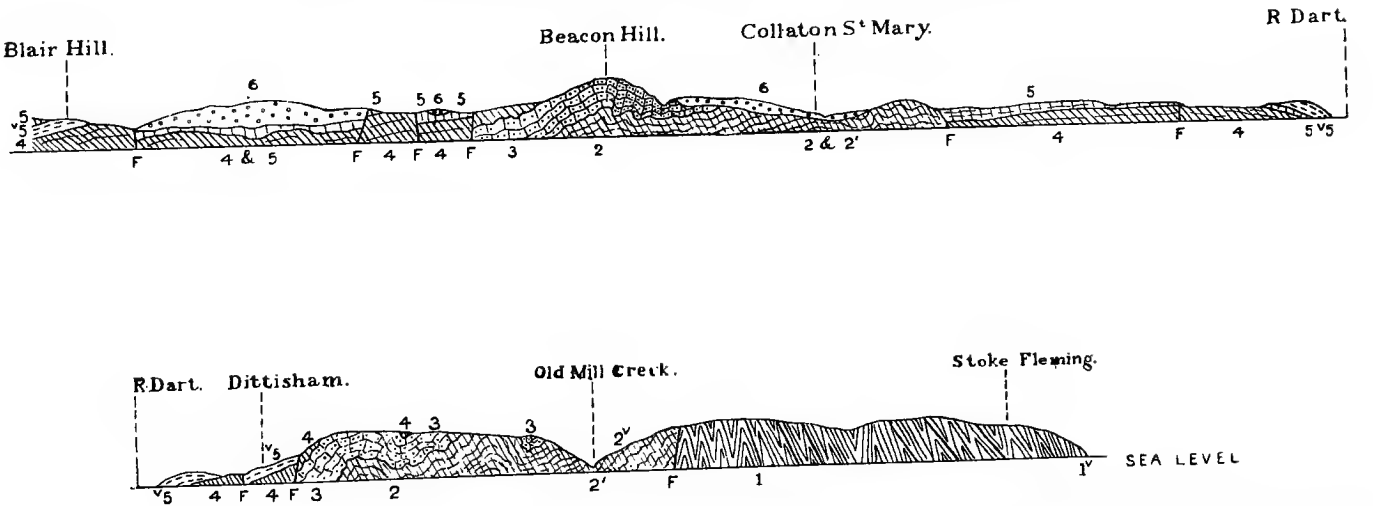
HORIZONTAL SECTIONS.

1 to 140, 146 to 148, price 5*s.* each.

VERTICAL SECTIONS.

1 to 86, price 3*s.* 6*d.* each.

Fig. 1.—Section North and South through Dittisham to Stoke Fleming.



Lower Devonian = 1, 2′, 2, 3 { 1—Dartmouth Slates. 2′—Representatives of Looe Beds including Long Sands Grit. 2—Meadfoot Beds 3—Staddon Grits. 1 V.—Volcanic Rocks in or on Dartmouth Slates. 2 V.—Line on which igneous rocks occur in No. 2′ or 2.

Middle Devonian = 4, 5, V 5 4—Eifelian Slates. 5—Eifelian and lower part of Middle Devonian Limestone. V 5—Volcanic Rocks.

Lower New Red Rocks— 6—Conglomerate, Breccia and Sand. F—Faults.

350.

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF

THE COUNTRY AROUND

TORQUAY.

(Explanation of Sheet 350.)

BY

W. A. E. USSHER, F.G.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.

LONDON:
PRINTED FOR HIS MAJESTY'S STATIONERY OFFICE
BY WYMAN AND SONS, LIMITED, FETTER LANE, E.C.

And to be purchased from
E. STANFORD, 12, 13, and 14, Long Acre, London;
JOHN MENZIES and CO., Rose Street, Edinburgh;
HODGES, FIGGIS, and CO., 104, Grafton Street, Dublin;
From any Agent for the sale of Ordnance Survey Maps; or through any Bookseller from the Ordnance Survey Office, Southampton.

1903.

Price Two Shillings.

E.V

PREFACE.

The original geological map of this area which was published in 1840 was based on the field work of R. A. C. Godwin-Austen, whose Memoir "On the Geology of the south-east of Devonshire," may be regarded as the foundation of all subsequent geological work in the district. In 1868, Dr. Holl brought out a map in which additional details are given, and a few years later Mr. Arthur Champernowne commenced a careful survey of the neighbourhood of Totnes. The official re-examination of the area was begun in 1874-75 by Mr. H. B. Woodward, at Torquay, and Mr. Ussher, at Paignton.

Shortly before his death Mr. Champernowne generously handed over the results of his work to the Geological Survey, and the task of embodying these results in the official publications was entrusted to Mr. Ussher. About this time the six-inch ordance maps of the district were issued and it was found necessary to re-survey the whole area on this scale. This work has been carried out by Mr. Ussher, the results have been reduced to the one-inch scale and the map (New Series, sheet 350), was published in 1898. The present memoir is issued as an explanation of that map.

The district is one of exceptional difficulty, owing to the want of persistence in well marked lithological horizons and to stratigraphical complications of a most intricate character due to folding and faulting. Detailed work was therefore necessary before even the broader tectonic features could be made out. This work has, however, met with its reward. The three main divisions of the Devonian formation have not only been recognised, but their boundaries have been ascertained with at least approximate accuracy, and the rocks of the Torquay area have been brought into line with their continental equivalents.

Many workers have contributed to this result, and a general account of the extensive literature relating to the geology of the district is given in the introduction.

The six-inch maps have been deposited in the office for reference, and copies may be obtained at cost price.

J. J. H. TEALL,
Director.

Geological Survey Office,
28, Jermyn Street, London,
9th June, 1903.

CONTENTS.

LIST OF ILLUSTRATIONS.

GEOLOGY

OF THE COUNTRY AROUND

TORQUAY.

CHAPTER I.

INTRODUCTION.

Sheet 350 of the Geological Survey Map embraces an area of about 102 square miles in the south-eastern part of Devonshire, with a coast line of about 20 miles extending from Petitor beach round the Torquay promontory, by Paignton, Brixham and Berry Head, to Dartmouth Harbour, Stoke Fleming and Matthew's Point. The area is replete with interest from an archæological and historical, as well as from a geological point of view, and it possesses in Torquay a watering-place unrivalled in the south of England. The scenery is extremely diversified; steep rounded hills, rising here and there above 600 feet, are intersected by narrow combes or stream-valleys, and at Torquay and south of Paignton, limestone plateaux abut against the higher land. The river Dart and its tributaries drain most of the inland districts, the coast lands being watered by small streams having direct outlets to the sea. The Dart enters the area near Staverton, a locality renowned for its orchards, and, following a rather sinuous course of thirteen miles by Dartington Park, Totnes, Sharpham House and Dittisham, it empties itself into the sea below Kingswear and the town of Dartmouth.

Literature.

The earliest special references to the geology of the area embraced in Sheet 350, are to be found in the writings of De la Beche and Godwin-Austen, in the "Transactions of the Geological Society;" in De la Beche's "Report on the Geology of Cornwall, Devon and West Somerset," which was published in 1839, and in his "Geological Manual," second edition, 1832, page 401, and pages 496, 497. In the first section of "Memoirs of Geological Survey," vol. 1., 1846, page 89, he rightly places the Lower Devonian of Torquay and Paignton below the limestone. In 1829, De la

7052. 500—Wt. 22521. 8/03. Wy. & S. 1150r.

Beche described the New Red rocks of Tor and Babbacombe Bays.* He regarded the Devonian limestones as Carboniferous limestone and the Lower Devonian grit as Old Red Sandstone In 1842, Godwin-Austen combined four of his previous papers into a connected description, entitled "On the Geology of the south-east of Devonshire." This Memoir may be regarded as the foundation on which all subsequent geological work in the area was built; for, although De la Beche's Report antedated it, the Geology of South Devon, there described, was based on the field work of Godwin-Austen. The map accompanying Godwin-Austen's paper is, in many respects, a masterly production; as showing the general distribution of the Devonian limestones and the extension of the New Red rocks. It is a reduction from the old Geological Survey map done by him and presented to Government. In the text special references are made to the following phenomena:—The submerged forest ground of Torbay, the raised Beaches of Hope's Nose, the Thatcher rock and Brixham, Kent's Hole Cavern, the gravels of the Dart near Staverton, cleavage of slates and limestones in districts north of Totnes and near Brixham, the igneous rocks of Black Head and North Whilboro, the lateral forcing of large blocks of limestone into the slates at Petitor, disturbances at Petitor, Torquay, etc.†

Dr. Harvey B. Holl, in 1868, attempted the solution of the structure of the Older Rocks of South Devon and East Cornwall.‡ He placed the (Lower Devonian) grits of Cockington above the (Middle Devonian) limestones of Marldon, etc. In this error he was subsequently followed by Champernowne, although Mr. H. B. Woodward § had placed them in their true position some years previously.

The Cavern deposits of the area will ever be associated with the name of William Pengelly, and many references to the general and special geological phenomena will be found in the numerous papers contributed by him to the British Association, Devonshire Association, Royal Geological Society of Cornwall, Plymouth Institute, etc. A list of Pengelly's papers, and a digest of his scientific work, by Professor Bonney, will be found appended to the Biography by his daughter. In 1856, he called attention to the form of chalcedonic structure found coating limestone fragments in the New Red breccias of Torbay.‖ In 1861, contributions appeared on Brixham Cavern, and on recent encroachments of the sea on the shores of Torbay.¶ In 1862, the distribution of Devonian Fossils of Devon and Cornwall, and the correlation of the rocks with the Old Red Sandstone of Scotland was treated of.** In 1861, and following years, the

* *Trans. Geol. Soc.* Ser. 2. vol. iii., p. 161.
† *Trans. Geol. Soc.* Ser. 2. vol. vi., pp. 433 to 446, and 481 to 489.
‡ *Quart. Journ. Geol. Soc.*, vol. xxiv., p. 434.
§ *Geol. Mag.* for 1876, p. 576, and 1877, p. 449.
‖ *Rep. Brit. Assoc.* for 1856, *Trans. of Sections*, p. 74. In full in *Trans. Roy. Geol. Soc. Corn.* vol. vii., p. 309.
¶ *Rep. Brit. Assoc.* for 1861, p. 123. *Geologist*, vol. iv., pp. 153, 447 and 456.
** *Ibid.* vol. v. pp. 10, 74 and 456. *Rep. Brit. Assoc.* for 1862, p. 86.

New Red rocks were described.* In 1865 the first Report of the Committee for exploring Kent's Cavern appeared,† and also a paper in the Proceedings of the Royal Institution. In his contributions to the Devon Association from 1865 to 1888 will be found many papers referring to the submerged forests, raised beaches and other signs of elevation, and to the caverns and fissures of this area, besides commentaries on references to the district in contemporary literature. The titles of those referring to the area will be given in the Appendix. The literature of Kent's Cavern is also associated with the name of E. Vivian. He edited MacEnery's notes, besides other papers.‡

The late E. B. Tawney in 1870§ noted the discovery of fossils in the Lower Devonian rocks of Smugglers Cove and the coast west of Hope's Nose raised beach. Mr. H. B. Woodward gave the true position of the Cockington grits in 1876.‖ The discovery of Upper Devonian fossils at Saltern Cove by J. E. Lee was announced in 1877.¶ The discovery of *Calceola sandalina* at the base of the limestones of Daddy Hole plain, and the inverted structures in that part of the coast were recorded by Champernowne in 1874.** In 1878 Champernowne published his adhesion to Mr. Woodward's opinion in regard to the Cockington beds.†† In 1881 he announced the discovery of *Homalonotus* in the Lower Devonian rocks of Lincombe Hill,‡‡ and in 1884, described some Zaphrentoid corals from the Middle Devonian rocks of Mudstone Bay and Dartington.§§ In 1889 Champernowne's latest views (in which he advocated the Upper Devonian age of the Cockington grits) appeared in a most important paper on the Ashprington Volcanic series.‖‖

The Dartmouth slates, so named by Sedgwick,¶¶ who classed them with the Morte slates of North Devon, were left undefined as to position by Champernowne. He seems to have regarded them as a type, locally, representing the Middle Devonian.≈ The classification of the Devonian rocks in the area, just before the Geological Survey began its work in 1888, is given by Mr. Woodward.*†

In Davidson's "Supplement to the British Devonian Brachiopoda," pages 4 and 8, the discovery of Lower Devonian fossils in the railway cutting near Saltern Cove, and at Goodrington

* *Trans. Plymouth Instit.* for 1861–1863 and 1864–1865.

† *Rep. Brit. Assoc.* for 1865, p. 16 and in succeeding years up to (and inclusive of) 1878.

‡ *Ibid* for 1847, *Trans. of Sect.* p. 73; *Ibid* for 1856, *Trans. of Sect.* pp. 78 and 119.

§ *Trans. Devon. Assoc.* vol. iv., p. 291, etc.

‖ *Geol. Mag.*, 1876, p. 576. *Ibid*, 1877, p. 449.

¶ *Ibid*, 1877, p. 100.

** *Trans. Devon. Assoc.* for 1874.

†† *Geol. Mag.*, 1878, p. 193.

‡‡ *Ibid*, 1881, p. 487.

§§ *Quart. Journ. Geol. Soc.*, vol. xl., p. 497.

‖‖ *Ibid* vol. xlv., p. 369.

¶¶ *Quart. Journ. Geol. Soc.*, vol. viii., p. 3.

≈ Ussher. *Proc. Geologists Assoc.*, vol. viii., p. 442.

*† Geology of England and Wales, 2nd edition, 1887, pp. 130–139.

Sands, by the Rev. G. F. Whidborne, is recorded. The bearing of this discovery on the age of the Cockington beds was overlooked, perhaps because the prevalence of faults, and the occurrence of New Red rocks in the intervening distance, may have been thought to render it inconclusive.

The palæontology of the Lummaton limestone, which occurs on the north border of Sheet 350, has been thoroughly worked by Mr. Whidborne, and is described in a Monograph in the Palæontographical Society's publications between the years 1888 and 1896. Ostracods obtained in the Eifelian Limestone near Daddy Hole, Torquay, by Mr. Whidborne were described by Prof. T. R. Jones.*

In 1888 Mr A. R. Hunt contributed an important paper on "The Raised Beach on the Thatcher Rock, its Shells and their Teaching."† In "Notes on Torbay," by the same author,‡ valuable information as to the character of the bottom and of the submarine rock reefs in the bay is given. See also a paper "On Exposures of the Submerged Forest Clays at Paignton and Blackpool Beaches in April 1881."§ The Torbay submerged forest and the Hope's Nose raised beach were also referred to by the late D. Pidgeon.‖ Some of the pleistocene phenomena of the area have been incidentally referred to in a paper, "On the Chronological Value of the Pleistocene Deposits of Devon," by the writer. Amongst his papers the following have special reference to this area—"On the Age and Origin of the Watcombe Clay,"¶ "On the Geology of Paignton,"** "The Devonian Rocks of South Devon."†† The Devonian rocks of the area are also mentioned in classifications published in 1889‡‡ and 1891.§§

In an important paper "On the Microscopic Structure and Residues, insoluble in Hydrochloric Acid, of the Devonian limestones of South Devon,"‖‖ Mr. E. Wethered refers particularly to specimens from Hope's Nose, Daddy Hole, and Lummaton. The most important paper bearing on the correlation of the Devonian rocks of the area with those of the Continent, was contributed by Dr. Kayser in 1889.¶¶ There are few parts of South Devon which present such a copious geological literature.

General Geology and Cartography.

The geology of Sheet 350 is very complicated. The impersistence and variation in lithological characters, as well as the

* *Annals of Nat. Hist.*, Oct. 1888., p. 295.
† *Trans. Devon. Assoc.*, for 1888.
‡ *Ibid* for 1878.
§ *Ibid* for 1881.
‖ *Quart. Journ. Geol. Soc.*. vol. xli., p. 9, 1885, and *Ibid*, 1878, p. 451.
¶ *Trans. Devon. Assoc.* for 1877.
** *Ibid* for 1878.
†† *Quart. Journ. Geol. Soc.*, vol. xlvi., p. 487, &c., 1890.
‡‡ *Rep. Brit. Assoc., Trans. of Sect.*, and *Proc. Somerset Arch. and Nat. Hist. Society.*
§§ *Trans. R. Geol. Soc., Corn.*, pp. 282-285, and 316, 317, and 324.
‖‖ *Quart. Journ. Geol. Soc.*, vol. xlviii., p. 377, 1892.
¶¶ *Neues Jahrb. für Mineralogie*, etc., 1889, Band 1, Zeitsch. 189.

restriction of faunas to certain favoured localities, would alone constitute obstacles to a rapid geological survey; but, as there are also numerous faults repeating or cutting out horizons in a series of rocks everywhere contorted, the original Geological Ordnance Survey Map of this district cannot be regarded in any but the most general sense as the foundation of the present Survey Map. The earlier map showed Devonian, or "grauwacke," with masses of limestone and some patches of greenstone, overlaid by the New Red rocks of Paignton and Cockington, the boundaries of the latter being well drawn. The necessity for broad generalizations, during the rapid original survey, in indicating limestone and greenstone boundaries, could not result in the production of anything more than a sketch map.

The late A. Champernowne devoted most of his leisure time during many years to a stratigraphical study of the area. He placed the limestones in one general series; separated the Lower Devonian of the Torquay promontory, and near Sharkham Point and Dittisham; attracted attention to the fossiliferous Middle Devonian slates; and proved the development of a great volcanic series, corresponding in character to the Nassau schalsteins. Champernowne generously placed his field maps at the disposal of the Geological Survey. In reconciling the different versions on his maps, where he entertained doubts as to the structure or succession of the Devonian rocks of the Torquay and Paignton area, during a careful survey made on the then new 6-inch maps, the present map was evolved.

The discovery of an Upper Devonian fauna, of the Büdesheim type, by the late J. E. Lee at Saltern Cove, also afforded an invaluable basis of research, by which the structure of many parts of the district and the distribution of the Upper Devonian rocks was determined.

Through the kind offices of Messrs. Gosselet and Kayser, who identified fossils collected in the Lower Devonian districts during the earlier stages of the survey, representatives of Upper and Lower Coblenzian horizons were shown to occur in the Cockington and Paignton area. Champernowne had regarded the Cockington grits as of doubtful age, but possibly the representatives of the *Psammites de Condroz* of Belgium, and therefore Upper Devonian. The Lower Devonian rocks of the Dartmouth and Kingswear area, under the name "Dartmouth Slates," were left undefined as to position by Champernowne and the author, in classifications of 1889.

The survey of the Devonian rocks, begun in Sheets 339 and 350 in 1887, on the basis of Champernowne's map, has been carried on throughout South Devon and in East Cornwall as far as Looe and Liskeard. The Lower Devonian rocks have from the first occasioned the greatest difficulty. The absence of consecutive succession has necessitated very minute observation, the collection of many typical specimens, and the accumulation of problems, rather than of evidence for their solution. However, on reviewing all the work, it was found necessary to arrive at some general hypothetical succession which should be tested by

its efficacy in explaining the apparently conflicting evidences as to the composition and succession of the Lower Devonian rocks in different areas. The last area surveyed, that of Looe, clearly demonstrated the necessity for a reconsideration of the relations of the Lower Devonian rocks of this and the intervening areas.

Since 1898 this work had been rapidly carried on when opportunity offered, but the Lower Devonian coast line, south of Brixham, was not revisited until March, 1902, when it was brought into direct and satisfactory relation to all the other Lower Devonian coast sections as far west as Fowey. Local names were used to denote lithological types which appeared to have definite stratigraphical value; but the progress of the survey tends to show that, although indispensable to the investigator, the retention of local names (many of them synonyms), is a needless tax on the memory; for it must be borne in mind that (except in North Devon and West Somerset) the British Devonian had never been subdivided prior to the commencement of the present survey; whilst in France, Belgium, Germany and Russia, the main subdivisions and the faunas which characterise them had been carefully worked out. It is in these divisions or stages that we have to group the British Devonian rocks.

Of the two principal Continental types—the Franco-Belgian and the German—the Devonian rocks of South Devon approximate most closely to the latter, although the lithological characters of the correlative horizons are in some cases quite different. Thus the Upper Devonian shales of Büdesheim are very unlike the red slaty mudstones of Saltern and Silver coves, although characterised by a similar fauna. Still less do the Upper Devonian slates of South Devon resemble the Upper Devonian shales of the Ardennes. As regards the Upper Devonian, the chief lithological resemblances are to be found in the calcareous beds near the base of the Upper Devonian, in the Chudleigh, Torquay and Paignton districts. In these districts the decomposed calcareous nodules, characteristic of the *Knollen Kalk*, are occasionally met with in the slates; beds made up of almond-shaped concretions of compact limestone recall the German *Kramenzel*, and the shaly red *Goniatite* limestones of Lower Dunscombe, Petitor, etc., represent the *Goniatiten Schichten*. In the limestone masses, parts homotaxeous with the *Rhynchonella cuboides* zone and the Middle Devonian *Stringocephalus* limestone in their lithological variations are identical with continental equivalents; as also in the case of the lower beds of limestone, corresponding to the Eifelian limestones (*Calcaires de Couvin*). As regards the Lower Devonian the Meadfoot beds correspond in character more or less with the Lower Coblenzian, and the grits above them are more or less similar in character to the Upper Coblenzian. The mottled red and green slates of the Gedinnien resemble the Dartmouth slates, though not necessarily on the same horizon. For purposes of comparison or reference the continental horizons may be summarized as follows:—

	Franco-Belgian.	*German.*
Upper Devonian	Upper part Fammenien	Cypridinen Schiefer
	Lower part Frasnien	Knollen Kalk, Kramenzel Goniatiten Schichten Iberger Kalk
Middle Devonian (including Eifelian)	Calcaire de Givet	Stringocephalen Kalk
	Calcaires et schistes de Couvin	Calceolen or Eifler Kalk Calceolen Schiefer
Lower Devonian	Coblenzien Superieure	Ober Coblenz
	Coblenzien Inferieure	Unter Coblenz Hunsruckschiefer Taunusien
	Gedinnien	Gedinnien

A further correlation is made by the correspondence of the Middle Devonian volcanic rocks, south of Totnes, named the Ashprington series, with the schalsteins of Nassau. The general correlation of the Devonian rocks in Sheet 350 with those of the Continent is unquestionable.

Dr. Kayser* thus refers to the correspondences of South Devon and West German Devonian horizons:—"We find first of all in South Devon a development which in every aspect most intimately connects it with West Germany. In the Upper Devonian we have the Knollen Kalk with *Clymenia*, Cypridinen Schiefer, Adorf *Goniatite* limestone, Büdesheim shales and Iberg Coralline and Brachiopod limestone; in the Middle Devonian, *Stringocephalus* limestone, *Calceola* limestone, *Calceola* slates, and possibly also Goslar slates; finally in the Lower Devonian, Upper and Lower Coblenz beds and Siegener grauwacke—that this crops out at Looe in Cornwall I have already proved through a small but typical fauna—(*Jahrb. d. Kgl. Preuss. Geol. Landesanstalt*, 1882–3). This widespread agreement is strengthened by the appearance of numerous greenstones which are accompanied, as in Nassau and the Harz, by schalsteins [slaty sheared volcanic rocks] and contact rocks."

On the other hand, no boundary can be drawn for representatives of the *Rhynchonella cuboides* zone, as the Lummaton fauna proves the co-existence of *Rhynchonella cuboides* and *Stringocephalus*, and there is no lithological distinction by which such a line could be traced, if this were not the case.

As regards the Lower Devonian, the boundaries between the Warberry and Meadfoot beds cannot be proved to be a division between Upper and Lower Coblenzian, or even to possess absolute stratigraphical value, and although the Looe rocks have their equivalents in the area to the north of the Dartmouth slates, they cannot be separated out.

---

*Translated from *Neues Jahrb. für Mineralogie*, etc., 1889. Bd. 1. Zeitsch. 189.

Table of Formations with Foreign Equivalents and Localities.

Pleistocene	Alluvium		Of R. Dart and tributaries, and of streams with seaward outlets.
	River Terrace Gravels		Dart Valley above Totnes ; north of Paignton.
	Submerged Forests		Tor Abbey Sands, the Paignton Coast, Blackpool near Stoke Fleming.
	Head		Traces on Raised Beach Platforms at Hope's Nose, Churston Cove, &c., not shown on the Map.
	Raised Beaches		Hope's Nose, Thatcher Stone, Churston Cove, near Berry Head, Sharkham Point.
	Cavern Deposits		Kent's Cavern, Windmill Hill Cavern Brixham, Happaway Cavern, Anstey's Cove Cavern.
Lower New Red (*Permian*)	Conglomerate and Breccia with beds of Rock Sand		Oddicombe Beach, St. Marychurch, W. of Torquay, Paignton.
	Clays with sandy beds, Brecciated Clays		Petit Tor, N. of Torre Station, Edginswell, N. of Compton, &c.
	Sandstone outliers and in fissures in limestone		Outliers near Waddeton, Brixham, Durl Head ; fissures near Churston Cove and Berry Head.
Upper Devonian	Cypridinen Schiefer		Red and greenish slates with Entomostraca, Anstey's Cove, Goodrington.
	Büdesheim Schiefer		Red slates and slaty mudstone, Saltern Cove, Ivy Cove.
	Knollen-Kalk and Kramenzel		Slates, &c., with calcareous nodules, compact concretionary limestone, Saltern Cove, Ivy Cove, Ilsham.
	Goniatiten Schichten		Irregular liver-coloured shaly limestone, Petit Tor combe, Anstey's Cove, Ilsham.
Middle Devonian	Rhynchonella cuboides Zone		Pale massive sub-crystalline limestone, Lummaton, Petit Tor, Ilsham, &c. Bedded limestone, Goodrington, Elbury, &c.
	Stringocephalen-Kalk		Massive and bedded limestones mostly coralline, Babbacombe, Torquay, Brixham, Ipplepen, Marldon, Dartington.
	Stringocephalen-Schiefer		Slates replacing limestone in Dartington Park, Broadhempston, &c.
	Eifler-Kalk		Thin-bedded, slaty and shaly limestones, Hope's Nose, Redgate Beach, Daddy Hole, &c., Mudstone Bay, Harbertonford, &c.
	Eifler-Schiefer		Fossiliferous irregular, partly calcareous, slates, Berry Park ; more even slates, Mudstone Bay anticline, &c.
Lower Devonian	Upper Coblenzien	Staddon Grits	Hard quartzose grits, red, dull green and grey grits, with slates and shales. Top beds west of Hope's Nose Raised Beach. Main outcrop from north end of Southdown Cliff westward, Warberry Hill, Lincombe Hill, Torquay, Cockington, &c.
	Lower Coblenzien and Taunusien (Siegener Grauwacke)	Meadfoot Beds, including Looe Beds	Dark grey slates, knubbly and irregular, with compact grit beds, and fossiliferous calcareous bands. Dark grey slates with silty films, occasional beds of grit, and lenticles of limestone. Beds of Looe and Ringmore type on coast, south of Man Sands locally red-stained.
	Gedinnien (?)	Dartmouth Slates	Variegated, purple, green, &c., glossy slates, grit shales (quartzophyllades), and occasional beds of hard grit. Scabbacombe Head to S.W. corner of map.

The Ashprington volcanic rocks, consisting of shalsteins, tuffs, and hard diabases, occupy a considerable area south and south-east of Totnes. The Eifelian limestones, which emerge from beneath them near Dittisham, Cornworthy, etc., prove that the earlier eruptions took place during, or immediately preceding, the deposition of the Eifelian limestones. The distribution of the Brixham and Yalberton limestone masses with reference to them justifies the inference that volcanic rocks in this area of maximum vulcanicity locally represent the Middle Devonian limestone masses. Although the Ashprington area furnishes no evidence of the date of the most recent eruptions, it is very probable that these were coeval with emanations from local foci, which in some cases, as at Black Head, Goodrington, etc., obscure the relations of the Upper and Middle Devonian, and may have been protracted to a stage as high as the Goniatite beds near the base of the former.

TABLE OF IGNEOUS ROCKS.

UPPER DEVONIAN	Calcareous Tuffs -		Ansteys Cove, Black Head.
	Diabase of Black Head?		(Carey Arms, Babbacombe?)
	Felspathic Tuffs in slates		Hookwells, West of Churston Cove.
UPPER AND MIDDLE DEVONIAN (About the Stage of Rhynchonella cuboides Beds)	Schalsteins, &c.-		Black Head, Saltern Cove, Goodrington. Crabs Park, volcanic rocks in part. Ashprington, volcanic rocks in part.
MIDDLE DEVONIAN (including Eifelian Limestone)	Schalsteins, Tuffs, Diabases		Crabs Park, volcanic rocks in part. Ashprington volcanic area, Sharkham Point. Dartington Park, &c., Blair Hill, Babbacombe Cliff. Two Bands in Limestones of Hope's Nose.
LOWER DEVONIAN	In Meadfoot Beds or representatives of Looe Beds	Sheared Diabases (probably in part contemporaneous)	Southdown Cliff, S. of Crabrock Point. Near Nethway House, Sandquay. Townstal, Lower Norton, Bugford.
	In or on Dartmouth Slates	Sheared Diabases and Felspathic Tuffs?	Coast of Kingswear Promontory. Stoke Fleming Coast and Blackpool Valley; Brookhill (near Kingswear), Hansel, &c.

The boundary lines on the map, as regards the Devonian rocks, are only stratigraphical so far as the characters by which

they were drawn may be regarded as persistent or reliable indications of stratigraphical horizons. The uncertain value of colour distinctions and lithological distinctions which may have been produced by secondary agencies must be taken into account. In parts of the area it is uncertain to what extent slates may represent the limestones, and this is of course naturally the case as regards volcanic rocks, there being no evidence to show the date of the upward limit of the Ashprington volcanic series. As regards the Lower Devonian, the darker tint on the map denotes the prevalence of grits in the Upper beds (the Staddon grit series) which may be regarded as roughly homotaxeous with the Upper Coblenzian; but it also includes red-stained Meadfoot beds, which cannot be separated in the Paignton area, and developments of grit in that series. The Dartmouth slate group does not occur in the Torquay and Paignton areas. The boundary between this series and the Meadfoot beds, west of Stoke Fleming, owing to the absence of marked lithological distinctions in the slates, and the danger in placing too much reliance on colour, the almost indefinite repetition of junction beds, and bad preservation of fossils and lack of time to search for them, is not satisfactory although carefully drawn.

Structure.

The district is cut up by numerous faults resulting from the compression and contortion of a complex group of rocks of different degrees of hardness, and the contortions exhibited by the older rocks, even where exposed in section, are often so broken by small slides and faults, that it is not easy to trace their effects with certainty. Owing to the shearing to which inverted contortions have been subjected, many small slides or thrusts have taken place throughout South Devon, and these, in homogeneous rocks, tend in some cases to obscure both bedding and cleavage. Sections prove that appearances of horizontal bedding are sometimes due to more or less sharp zig-zag plication, and this structure, accompanied by small thrusts and faults, may produce an apparent dovetailing between different members of the Devonian series; as in the Petitor syncline. Where junctions are not actually exposed, it is in many cases impossible to say whether they are faulted or natural. As the evidence for a comparatively trivial fault may be marked whilst an important one cannot be traced, the presence of fault lines on the map in one part of the district and their absence in another, as for instance in the Torquay area, and in the area south of the Dart, is no proof whatever of their prevalence in the one district more than in the other. In tracing a comparatively distinct boundary, such as that of the Lower Devonian grits, westward from Sharkham Point, which is almost invariably marked by feature (the older rock occupying the higher ground), there is a strong *à priori* reason for inferring fault and thrust boundaries, but their position, as south of Brixham, after the evidence had been completely exhausted,

remains doubtful. Where the Lower Devonian is in contact with the Upper on the north of Goodrington, there is a reversed fault or thrust boundary of considerable magnitude, which is prolonged round a part of the Lower Devonian of the Paignton area and shifted by cross faults. In spite of these remarks it must not be inferred that the Devonian rocks are quite dismembered by thrusts. Thrusts and faults have taken place in consequence of the minor foldings and contortion of the rocks, producing numerous minor displacements, but the larger dislocations have a direct relation to the main structural curves as may be seen on either side of the Middle Devonian syncline between Paignton and Man Sands, and there is no proof of the rocks being anywhere thrust out of their true relative position.

A map on the one-inch scale is too small to enable us to depict the geology in a wholly satisfactory manner, as minutiæ of considerable local interest and importance cannot be adequately shown upon it.

The map is not overburdened with dips, because their amount and direction are of little consequence in an area where the rocks are thrown into sharply inverted folds, and are seldom observable free from contortion or fault for many yards.

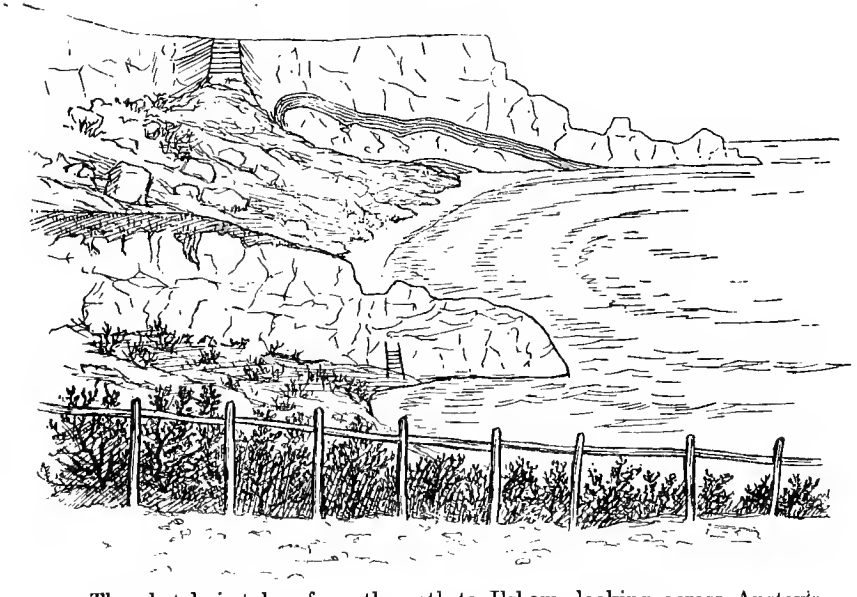
General Structure.

The indications of southerly dips, prevalent in the southern parts of the area, show that the axes of the folds are inverted toward the north. Although the constant evidences of disturbance and dislocation, met with in the area, naturally tend to obscure the true value and persistence of lithological and palaeontological horizons, their effect on the general continuity and structure of the rocks is less than might be supposed.

Striking east and west the main Lower Devonian outcrop terminates in Southdown Cliff, just south of Sharkham Point. It is separated on the north from the Lower Devonian (which bounds the New Red rocks of Paignton) by Middle Devonian slates, limestones and volcanic rocks; whilst, still further north, the Lower Devonian rocks of Torquay are separated from those of Cockington by Middle Devonian slates and limestones. Hence it follows that the limestone of Berry Head occupies a syncline troughing out eastward; the Paignton area, an anticline terminating westward, and the Torquay promontory, an anticlinal dome or offset from the Paignton anticline. The effect of these structures is to produce a great superficial representation of the Middle Devonian rocks, through the flattening or dying out westward of the great structural folds in a series of curves, repeating the beds with an endless accompaniment of small contortions. The map does not show this disposition of the Middle Devonian rocks because of the impersistence of the limestones, through their replacement by volcanic rocks ("The Ashprington series" of Champernowne) in the district south of Totnes, and by slates in the Dartington and Broadhempston districts. Another effect of the general structure is the

greater dislocation and displacement of the rocks in the vicinity of the Lower Devonian anticlines. Thus, wherever Middle Devonian limestones are in contact with Lower Devonian rocks, a thickness of at least 170 feet of Eifelian slates has been cut out by fault or thrust; wherever Upper Devonian rocks, as at Saltern Cove, are in contact with the Lower Devonian, at least 400 feet of Middle Devonian rocks are missing. Upper Devonian rocks have been identified at Petitor, Anstey's Cove, and Ilsham, on the flanks of the Torquay anticline, and at Saltern Cove, Goodrington, Elbury and Silver Cove on the south of the Paignton anticline; yet in the district between Ipplepen and Totnes, away from the Lower Devonian rocks, we have no proof of the occurrence of Upper Devonian, and may, therefore, safely infer that—neither the dislocations nor the folds are of sufficient magnitude to trough them in.

Fig 2.—View across Redgate Beach.



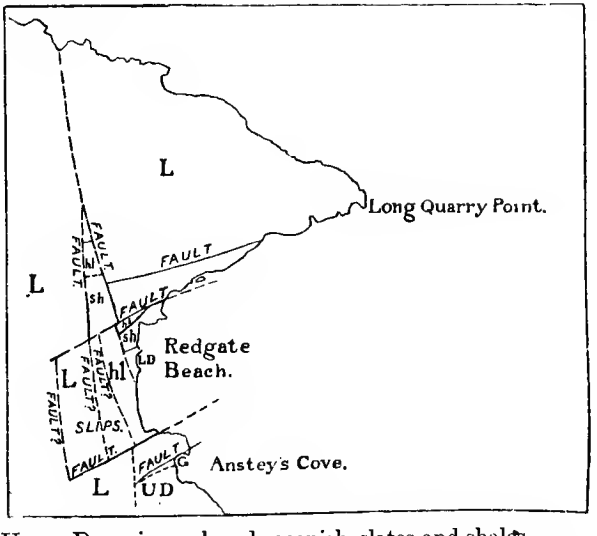
The sketch is taken from the path to Ilsham, looking across Anstey's Cove, Devil's Point and Redgate Beach, to Long Quarry Point. At the step-ladder red shale and shaly limestone (Upper Devonian) overlie the Devil's Point limestone, which may represent the *Rhynchonella cuboides* beds. On the further side of Devil's Point is Redgate Beach, at the foot of a tumbled slope of slips and debris from a cliff of contorted and faulted Middle Devonian limestone, there is a partial exposure of Lower Devonian shale and grit under dark Eifelian shales. Beyond is the limestone (Middle Devonian or *R. cuboides* beds) plateau of Babbacombe Downs. Along the cliff face dark Eifelian limestones, plicated with a mass of grey milestone, are shown; these beds slope outward from the face of the cliff which coincides with a fault by which they are brought up to the south. The cliff face is also broken by two cross faults, facing the spectator: between these red shaly limestones (probably Eifelian) are brought up, and appear to rest on the slates. The broken ground masks numerous faults slips, talus, and limestone blocks.

From what has gone before it may be regarded as a truism to point out, that comparative breadth of outcrop affords no indication of the thickness of any group in the Devonian series.

Fig. 2 has been selected as the best illustration of the complexity of structure and presence of faults in the vicinity of the great structural curves. The distance represented is not more than from twenty-three to twenty-five chains, and in it rocks of Upper, Middle, and Lower Devonian age occur. It also illustrates the character of the limestone plateaux and the erosion of the softer strata along lines of weakness.

The cliff face of contorted Middle Devonian limestone, parallel with Redgate beach, and coming toward the spectator, cannot, of course, be shown; but the tumbled masses of limestone and broken ground, at the foot of this cliff face, is due to slips, occasioned by faults and cracks on the down, parallel with

Fig. 3.—Sketch Map of Redgate Beach, (Scale 6 inches=1 mile).



UD. Upper Devonian red and greenish slates and shales.
G. Apparently shaly Goniatite-limestone with calcareous tuff.
L. Middle Devonian limestone.
hl. Thin dark limestone (Hope's Nose beds apparently) faulted against the limestone cliff and folded round pale-grey rather thin-bedded limestone; and reddish thin-bedded limestone.
sh. Reddish and dark-grey shales (Eifelian).
LD. Lower Devonian, red shales and red-brown grit, and grey slates with occasional beds of grey grit. Largely concealed by talus.

the cliff edge, in beds of limestone dipping seaward at a comparatively low angle. Fig. 3 shows the locality in plan. Fig, 1 (Frontispiece) is a section drawn across the map due north from Stoke Fleming. It shows the Paignton anticline and main outcrop of the Lower Devonian rocks.

CHAPTER II.

LOWER DEVONIAN.

The Lower Devonian rocks of the area consist of slates and grits irregularly associated.

The slates vary from purely argillaceous to fine silty, more or less siliceous, sediment, and these varieties are frequently found interlaminated or interbanded. For instance, at the north end of Long Sands, at Scabbacombe Sand, etc., on the coast south of Berry Head. The siliceous slates locally become welded into masses of hard compact grit.

The slates, through coincidence of bedding with the prevalent southerly dips of schistosity, frequently present the appearance of shales, and, where associated with hard beds of grit, as in the coast north of Man Sands, or rendered intractable by silty admixture, they become shales; the tendency to cleavage in the latter case being often shown by the undulation or incipient gnarling of their planes. The grits vary from a fine grained rock to a hard silty mudstone; they are more or less felspathic. The relatively coarser grained and more distinctly quartzose grits are granular, or assume the character of quartzite. Of the former the red speckled grits of Warberry Hill constitute an easily recognizable type, which is met with here and there as the Lower Devonian rocks are followed along their strike into Cornwall. Of the latter typical examples are furnished by grit bands and masses associated with the variegated slates of Kingswear promontory. The more felspathic varieties, and the finer silty sediments form hard or dense grits or siltstones.

Strings, lenticles, or bands of limestone are found in the slates; they are mainly of organic origin and are often completely altered. by the dissolution of the lime, into brown friable compressed residues. The presence of these bands furnishes a much more reliable guide to the classification and structure of the Lower Devonian rocks than is to be obtained by a study of the character and distribution of the grits, and the distribution of colouring matter.

Looked at broadly, grits are of more frequent occurrence in the upper part of the Lower Devonian where the arenaceous or granular varieties prevail; lower down they usually occur in intercalated beds, bands, or seams, and are more close textured and silty. The arenaceous rocks are generally reddish, red-brown, or dull green, and the associated slates reddish or grey. The compact grits are more often grey or brown; where this is the case they have been called Meadfoot beds, but where red they cannot be separated from the overlying types. Champernowne gave to the upper series the name of "The Lincombe,

Warberry and Smugglers Cove Grits," but the term "Staddon Grits" used by Holl is the best general term—they are developed on Staddon Heights south of Plymouth.

The term "Meadfoot Beds" was applied by Pengelly to dark slates and mudstones, with beds of compact grit and calcareous fossiliferous bands, which form the cliffs under Kilmorey and above the north part of Meadfoot Sands. These beds constitute a passage between the Lower Devonian rocks, where grits are prevalent, and the slates where they are of less frequent occurrence. The uppermost beds of the Meadfoot series are therefore sometimes mapped with the Staddon grits, and sometimes separated according to the vagaries of colour distinction. In the Paignton anticlinal the prevailing red colour prevents any boundary being drawn between the Staddon grits and Meadfoot beds. The main mass of this series consists of grey slates, locally red-stained, containing films or lenticles of limestone in places, occasional bands of hard grit and siliceous or silty interfilmings. In the area occupied by the group, it will be seen that grits have been mapped, notably the mass extending westward from Long Sands. These are coloured the same tint as the Staddon beds and they may be synclines of the basement beds of that group or of the grits in the upper beds of the Meadfoot series. Their occurrence is analogous to the grits of Looe and Beesands (Beeson) near Torcross (in sheet 356), in which rocks of the Warberry type are common. The rocks of the Torcross and Kingsbridge districts, as well as the various types of the Looe fossiliferous rocks, are all included in the Meadfoot series.

Below this group come the Dartmouth slates, a name given by Sedgwick to the glossy lilac, purple, and green variegated slates occurring south of Dartmouth and east of Kingswear. Beds of grit and quartzite occur in this group. Its relative position was unknown prior to the year 1898, during which the Looe area was surveyed and the Dartmouth slates proved to be continuous with the Polperro beds. When the map (350) was published, June 1898, the Dartmouth slates, although separated by a broken line, were not differentiated by colour. As in the case of the Staddon grits, the junction of the Dartmouth slates with the Meadfoot series is most uncertain. During the survey of the district a sharp colour distinction between dark slates (regarded as Meadfoot Beds) and lilac, red or purple, and green variegated slates, was taken as a boundary line, but on revisiting the Kingswear promontory (in 1902) it was found that red slates and grits with limestone of the Looe type had, through dependence on colour, been included in the Dartmouth slates, the boundary being further south than the broken line on the map.

There is no evidence of the presence of the Dartmouth slates at the surface in the Paignton and Torquay anticlines, and these are so broken up by faults that the structure of the Lower Devonian rocks can only be made out by a study of the main outcrop in the southern part of the map. In this area the coast section between Scabbacombe Head and Sharkham Point furnishes the best and most continuous exposure.

Proceeding northward along the coast, the greenish, purple, red and grey, partly siliceous slates of the Dartmouth group, with grey or green beds of hard grit or quartzite here and there, are associated with sheared igneous rock (perhaps originally a felspathic tuff of a type met with in the same series at Brook Hill near Kingswear, etc.) at a few chains north of Scabbacombe Head. At a few chains further north the red shaly grit and slate fragments on the surface contain fossils and brown friable seams which are the only indication that we have passed into the Meadfoot group. The coast being here inaccessible, it is impossible to say whether the junction is a natural one or faulted. The same beds are exposed at the Post Office, Kingswear. The cliff at the south end of Scabbacombe Sands consists of dark grey slates invertedly overlain by red, partly siliceous, slates with bands, films, and lenticles of red crinoidal limestone, in which irregular white streaks of calc spar replace organisms which were probably for the most part Monticuliporoid corals. A large fallen block of red limestone with the same white markings, is identical in every respect with red and dark grey limestone associated with the Looe grits on East Looe Beach and with the dark grey slates in junction with them at Millendreath. In the intervening coast sections there are similar limestones in the cliffs under Tregantle Fort; south of Plymouth between Crownhill Bay and Andurn Point; between Westcombe Beach and Armour (or Ayrmer) Cove near Ringmore, and by the River Avon between Sharpland and Cockridge Points.

Proceeding northward we encounter successively dark grey slates, contorted in places, grey slates with bands of grit and paler silty interlamination; a thrust fault bringing on dark slates with hard black patches, possibly fish remains, and limestone films with *Zaphrentis* and crinoids, then dark grey slates mottled with bright red (ologiste) splotches. These beds are succeeded by the Long Sands grits, dense, often thick bedded, arenaceous or silty rocks evidently much disturbed. In one spot small fossil markings, resembling Gasteropods, were observed in a hæmatitic patch on the surface of a bed. Small included fragments of buff slate or shale, are occasionally met with, particularly in one thin band. This is a phenomenon exhibited by the Looe grits and by the Staddon grits, and may be due to contemporaneous deposition or erosion.

The grits are associated with pale reddish slates, and apparently much contorted; they are continuously exposed in the low shore cliff, and make a vertically contorted junction with dark slates, in which a fragment of a Pachyporoid coral replaced by quartz was found. A little further north the slates exhibit silty interbanding; at the north end of the sands they contain small black patches, one of which revealed the structure of a *Pteraspis* plate. At the point, further on, limestone films with the (Monticuliporoid?) markings previously described are to be seen, near dark slates with bands of pale coloured igneous rock similar to the rocks in the Torcross section. The prolongation of this horizon westward would connect it with the traces of igneous

rocks found in the grey slates of the Nethway House Valley. Further north the slates become reddish, and contain films of crinoidal limestone, then dark grey, containing bands and lenticles of (Monticuliporoid ?) limestone similar to that in the red beds at the south end of Scabbacombe Sands; we next encounter traces of igneous rock of the Torcross type at the projection of Crabrock Point, round which it was impossible to proceed.

On the north side of Crabrock Point at the south end of Man Sands the section consists of dark grey slates with occasional seams of hard grit, veins of quartz and calcite, and interlaminated beds of Torcross and Tinsey Head types. Dark slates with occasional pyritous nodules prevail for about six chains beyond Man Sands Cottage, in the lower part of Southdown Cliff. The dark slates become blended with reddish coloured slates further north, and the schistosity is, in places, crossed by hard red decomposed fossiliferous bands, no doubt originally more or less calcareous, and occasionally forming bands or films of crinoidal limestone. A decomposed red-brown sheared igneous rock, about 2 feet thick, was noticed in these beds. At about twenty-five chains from Man Sands Cottage the section is broken by great tumbled blocks of hard grit, which occurs in thick bedded masses and in single beds in lilac-red and greyish slates, and both in the larger tumbled masses, and in low cliff exposures exhibits many inverted curves. These grits are very hard and compact, and in brown weathered patches there are traces of fossils, which, owing to the toughness of the rock, cannot be extracted by the use of an ordinary geological hammer. The appearance of these rocks connects them with the hard brown grits exposed in the New Drive near Hope's Nose, in which *Homalonotus* remains are abundant. The association of hard masses and beds of grit with reddish or grey slates continues for about ten chains north from the projection of the coast beyond Man Sands. Grey slates then prevail for about 60 yards, and overlie invertedly, reddish and grey slates with beds of hard grit, and red-brown shaly, more or less, micaceous sandstone. These show many inverted curves, and appear to constitute the base of the Staddon grit group, being cut off by a north-west and south-east fault, bringing up Aphanite and volcanic rocks of Middle Devonian (probably Eifelian) age.

In this section the obvious resemblance of the limestones, whether occurring as bands, films, or impersistent lenticles of some thickness, at the south end of Scabbacombe Sands to those south of Crabrock Point (whether the organisms are Monticuliporoid corals or not), leaves no doubt as to their being repetitions of the same horizon. There is every reason to conclude that the sequence from Man Sands northward is a gradually ascending one. Whether the hard grit beds and masses on the south of the Staddon grits should be embraced in that series, or in the upper part of the Meadfoot group, must remain a question awaiting the collection of characteristic fossils.

The discovery of *Pteraspis* at the north end of Long Sands, is a corroboration of similar finds in the dark slates of Looe above

the variegated Dartmouth slates, and by Mr. Brook-Fox in the grey slates of Armour (Ayrmer) Cove (sheet 355). It is certainly suggestive of the proximity of the Dartmouth slates, but, on the other hand, the upward range of *Pteraspis* has never been ascertained in these rocks, and hard black patches are of common occurrence in the grey slates of the Plymouth section at higher horizons, and exactly similar to those in the slates on the north and on the south of the Long Sands grits.

The coast being inaccessible toward Scabbacombe Head (as previously mentioned), it is impossible to say whether the Dartmouth slate boundary is natural or faulted. Though the latter supposition is rendered probable by the usual intervention of dark slates between the Dartmouth slate and the red or grey fossiliferous beds of Looe, yet the local upward extension of red colouring matter would render such an intervening series indistinguishable from the rocks above and below.

As regards the Long Sands grits and dense silty mudstones, the boundaries and colouring on the map suggest a repetition of higher beds, which cannot be assumed in the face of the occurrence of masses of silty rock in association with the slates not far above the Dartmouth series in the Looe area.

The Lower Devonian rocks exposed in the River Dart sections appear to be in unfaulted relation to the Eifelian (or lower Middle Devonian) slates; consequently the Staddon grits are better developed than on the coast. Their normal type is greenish, dull purple, brown, and reddish, more or less micaceous sandstones or fine grits, in thick or shaly beds, associated in variable proportions with reddish or greyish slates. Hard grey and red quartzose grits, similar to the upper beds of the group, shown in the coast section near Hope's Nose Raised Beach, are also present. A few feet of peroxidated igneous rock, probably intrusive, was noticed in the Staddon grits at Lower Kilngate.

The junction of the Staddon and Meadfoot beds is concealed by Noss Creek, but the latter series is typically exposed in Higher Noss Point, consisting of grey slates with hard beds of compact grit in places, and bands and lenticles of fossiliferous limestone, more or less siliceous, and often decomposed to brown residua. Near Lower Noss Point brown weathered siliceous limestone bands yielded crushed Spirifers, regarded by Mr. E. T. Newton as similar to *Sp. primæva* or *Sp. Decheni*. On the west bank of the river, hard brown grits are more prevalent in the Meadfoot slates; they seem to be contorted impersistent developments similar to those on the south of the Staddon grits in the coast section, although not continuously traceable in the intervening district. The shores of Old Mill Creek exhibit bands and lenticles of limestone, and of decomposed fossiliferous material; and sheared igneous bands, probably volcanic, also occur in the grey slates. These are probably the westerly continuation of the calcareous beds near Lower Noss Point. At a spring on the south border of Sandquay Wood, near the Naval Establishment, variegated slates of the Dartmouth slate type are exposed. If this is not due to local staining in the

Meadfoot beds, they owe their position to faults and disturbances, to which the absence of a close correspondence in the sections exposed on either side of the Dart is no doubt due. On the east side disturbances are marked by developments of quartz in masses, and in veins interlacing grit beds, near the Old Rock Inn, Ferry. Further south, 25 to 30 feet of brown weathered grit is exposed. If dips can be relied on, this horizon is repeated further south in two bands, which coalesce, through the dying out of the folds in the intervening slate, to form the irregular mass shown on the map. These grits are probably a faulted continuation or a folded repetition of the grits of Long Sands, on the coast, which have been traced westward to Waterhead Brake, but do not appear to cross Waterhead Creek. On the west bank of the river the same horizon is represented in the north of Dartmouth by reddish slates with grits and sandstones, which are apparently in faulted junction with the Dartmouth slates. These have been traced westward for more than three miles.

On the north of this gritty development, igneous patches or impersistent bands occur in the slates, commencing at Sandquay quarry with rocks resembling sheared tuffs and with porphyritic diabase. Although the masses of Aphanite, etc., shown on the map may be intrusive, impersistent bands which cannot be shown suggest contemporaneous vulcanicity and co-relation with similar phenomena in the valley at Nethway House, and on the north of Long Sands.

A section taken across the strike of the Lower Devonian at Blackawton shows greater repetition of horizons than the Dart or Coast sections. The Staddon grits are repeated by a syncline at Blackawton, which can be traced to a connection with their main outcrop at Capton. The intervening anticline of Meadfoot beds is complicated by numerous folds, owing to the plicated repetition of the Staddon grits on the western border of the map. The grits mapped at Hutcherleigh may be a repetition of the Staddon group, or a continuation of the Long Sands grit horizon, as they appear to be connected with the latter by arenaceous mudstones and laminated gritty beds, visible in the slates at Washwalk, Millcombe Bridge and Pruston Barton.

Further south, the lower horizons of the Meadfoot group are kept at the surface by innumerable, apparently small, contortions. No fossils were obtained, although brown friable material was noticed in the slates in places. Green and purple slates belonging to the Dartmouth slates occur at Combe on the western margin of the map, and between America Wood, Higher Wallaton Cross, and Abbotsleigh, lilac and purplish slates prevail, also suggestive of anticlines of Dartmouth slates. Besides these there may be other anticlines which have escaped detection. The main boundary drawn by colour distinction is very irregular and so unsatisfactory that no attempt was made to separate out occurrences of grey slate in the Dartmouth slate areas in the Kingswear promontory, and near Stoke Fleming; although it is probable that the igneous rocks of these districts occur on

the same geological horizon as those near Tor, Leader Wood and Buckland near the southern margin of the map.

This uncertainty cannot invalidate the conclusion that the groups are kept at the surface by shallow repeating curves or contortions in this part of the area, just as the Middle Devonian rocks are repeated at the termination of the great structural anticline of the Paignton area.

Through the sections across the main outcrop of the Lower Devonian we learn that the general descending sequence is as follows :—

1. Grits, sandstones, and gritty shales associated with slates and shales and generally reddish, greenish, or brownish in colour. (Staddon grits.)
2. Dark-grey, pale weathered slates and shales with beds of grit, occasional impersistent bands of siliceous limestone, and gritty films. In this series impersistent masses of grit occur. (Meadfoot group.)
3. Purple, lilac, buff and green glossy slates with beds of hard grit or quartzite. (Dartmouth slates or Polperro beds.)

The junction between 2 and 3 is so vague that, although very unlikely, it is by no means absolutely certain that the volcanic rocks in 2, near Dartmouth, may not be the same series as the volcanic rocks on the Kingswear and Stoke Fleming coasts, and in the Blackpool Valley.* This uncertainty is due to the absence of characters sufficiently marked to detect the basement beds of number 2, if present, in certain parts of the Dartmouth slate areas.

In general types the Staddon and Meadfoot groups correspond to the Upper and Lower Coblenzian of parts of Germany, and are homotaxeous with them. From this it must not be inferred that the lower part of the Meadfoot group may not correspond to strata older than the Lower Coblenzian, or that the upper beds of that group may not be in part Upper Coblenzian. The solution of this question involves a special search for fossils, for which there was no time during the survey of the area. In the following notes, commencing with the lower strata, we shall endeavour to keep each group separate as far as possible.

Dartmouth Slates.

The area was mapped in 1890–91 in entire ignorance of the connection of these beds with the variegated slates of Polperro, which was not clearly established until the survey of the Looe area in 1899. Taking the Looe district as the standard, both as regards lithological characters and relations, the Dartmouth and Polperro slates are identical. The variegated slates of Polperro and Downderry, where unfaulted, are in contact

* Such a correlation would make the grits between Long Sands and Cotterbury (near Blackawton), difficult to account for, except as an anticline of the upper beds of the Dartmouth slates.

with a dark slate series which separates them from grits. At Looe *Pteraspis* remains have been found on the coast in the dark slates, and these slates are often mottled with red (ologiste) splotches. It is, therefore, highly probable that there is an insensible passage from the *Pteraspis* beds to the Meadfoot group; and that a boundary drawn by colour characteristics may, in one place, exclude dark slates which belong to the Dartmouth slate series and, in another, include coloured slates which should be referred to the higher group.

In the Dartmouth slate districts between Scabbacombe Head and Stoke Fleming grey slates are frequently met with. Their presence suggests the occurrence of synclines of the basement beds of the overlying series which cannot be traced through the irregular distribution of colouring matter. Beyond all question, in the distinction of the different groups of the Lower Devonian colours are of great general value, but utterly unreliable, where unaccompanied by lithological distinction, as a guide to absolute stratigraphical boundaries. It is necessary to insist on this, as the boundaries of the Dartmouth slates west of Stoke Fleming are entirely dependent on colour distinctions. Guided by these alone the evidence in the south-western part of this area (and in the adjacent map, sheet 356) shows the gradual disappearance of this group westward through a series of anticlinal plications. This theory is borne out by the fact that, as a whole, the Dartmouth slate series is easily recognisable throughout its extension from Polperro in Cornwall to Modbury in Devon, but where in unfaulted junction with a grey slate series the boundary is nearly always more or less indefinite.

The Dartmouth slates are, as a group, characterised by the general prevalence of lilac, red, green and purple tints, often delicately blended with greys. Their glossy surfaces and reddish and purplish tints often exhibit much resemblance to varieties of the Gedinnien slates in the Ardennes. Siliceous shales (Quartzo-phyllades) are common in the series and, in the districts south of Dartmouth, may represent the grit intercalations which are often conspicuous in the Kingswear promontory. The grit beds vary from hard dense grit and more or less hackly fractured quartzose grit to quartzite. On the east of Ivy Cove hard grey grits intersected by quartz veins rest in inverted synclinals on glossy pink and lilac-grey variegated slates, and form crags on the summit. Between this and Scabbacombe Head a mass of similar grits forms a promontory. The local character of such grit masses is exemplified on the Revelstoke and Wembury coasts, at Bindown and Congorlan Tor in the Looe area and elsewhere throughout the extension of the group. On the hill above Kingswear, grey and blue slates, mottled red in places, are associated with shaly grit and rest on purplish, reddish and greenish grey slates or shales, with numerous films of brown friable material, usually in small knubbly patches or lenticles between their planes. Contorted beds of hard grit are shown at the south end of a quarry in the slate; beds of

quartzose grit or quartzite are also shown in the south of Kingswear, where greenish and grey tints prevail.

Between Beacon House and Brookhill, the coast is accessible by a path and steps. Near this an igneous rock, probably a sheared felspathic tuff or lava, makes a contorted junction with the slates, crossing the cleavage of which both rocks partake. This sheared rock cannot be continuously traced, although it occurs near Scabbacombe Head and at Coleton. It forms a type here and there present throughout the extension of the Dartmouth slates.

At the cemetery west of Dartmouth a shaft was sunk to a depth of 59 feet, in pale lilac and reddish glossy slates with occasional films of soft brown powdery material. The occurrence of brown films, of which many more instances might be cited, suggests the decomposition of calcareous organisms.

Between Matthews Point and Landcombe Cove (in the adjacent map on the south, sheet 356) there are thin lenticles of limestone in the slates. One of these, a fine-textured red-purple band, seems to be wholly composed of small organisms, suggestive of fish-spines, etc., but not clear enough for identification. At Coleton and near Brookhill, east of Kingswear, the slates are often thickly studded with small bodies, which suggest scattered and crushed organisms. *Pteraspis* remains have not been found, but they have not been specially sought for, as the relations of the Dartmouth slates to the *Pteraspis* beds was not known until years after the mapping of the district. At Coleton, amongst the slates, sheared felspathic tuff may possibly occur, or cubes of pyrites decomposed and replaced by whitey buff material may have produced the effect. Near the Plymouth Brethren's Chapel at Blackpool the variegated glossy slates, in one place by the lane, resemble a highly sheared volcanic rock of the Brookhill type with felspars drawn out.

One of the chief difficulties in distinguishing sheared tuffs and lavas from sheared intrusive rocks is occasioned by the frequent coincidence in the direction of bedding and cleavage in the Dartmouth slates through the sharpness of the folds, the axes of which are often merely indicated by a thickening of the slate, and by the development of quartz veins. It is only when the series contains many intercalated beds of grit, as in the Revelstoke coast, that the eye can readily distinguish the constant over-folding of the beds, or where laminated grits traverse the cleavage in a wavy or puckered manner. In Mill Bay an appearance of unconformity in the series is probably due to a thrust. The igneous rocks occur in a way strongly suggestive of the plicated repetition of tuffs and lavas, either emitted from sources now beneath the sea or from local necks amongst or under them.

The character of the laminated grits as exemplified by a specimen obtained near Mill Hill Copse, west of Stoke Fleming, is thus described by Mr. Teall:—

3094 (130). Near Mill Hill Copse, west of Stoke Fleming.
A brownish grey puckered sandy Devonian shale containing small cubes of partially oxidized pyrite.

Under the microscope alternating laminæ of gritty and micaceous material. The micaceous laminæ show strain-slip cleavage exactly similar to that seen in the corresponding laminæ in the mica-schists. The strain-slips on opposite sides of an anticline dip outwards, and those on opposite sides of a syncline dip inwards.

The coarsest particles in the gritty layers are about ·1 mm. in diameter.

The micaceous layers are formed almost entirely of mica, which occurs both in the form of fairly large clastic flakes and also as extremely minute scales. The latter are associated with excessively fine micro- or crypto-crystalline material. Some of the gritty layers contain deep brown ferric oxide, which has probably been formed by the alteration of ferriferous carbonate. The micaceous minerals occur also in the gritty layers. This rock was evidently formed along the zone where fine sand shades into mud, and the conditions varied so as to give rise to alternations of finer and coarser sediment.

Meadfoot Beds and Staddon Grit.

For purposes of description the Lower Devonian rocks above the Dartmouth slates are naturally split up into the following districts—the southern district, or main outcrop, the Paignton anticline, and the Torquay anticline.

Southern District.

Meadfoot Beds.—These strata are so plicated and faulted that the appearance of the Dartmouth slates in anticlines in unexpected places may explain the following occurrences. Variegated slates on the south border of Sandquay Wood, near the Naval Establishment; a narrow strip of purple slates on the west of Uddern Copse (west of Ash and south of Paddlelake) at Hutcherleigh, and near Hoodown. As to the Long Sands, Dartmouth and Townstal grit, its boundaries, probably owing to the dying out of the grits in the reddish slates with which they are associated, are very indefinite near Nethway House. The faulted relation of these grits to the Dartmouth slates is nowhere seen, and the presence of rocks which might belong to the Dartmouth slates, and of grits in places (of Warberry and Looe types) renders the boundary uncertain. There seems to be, however, more evidence for regarding these grits as an impersistent development in the Meadfoot series than for their inclusion in the Dartmouth slates. The general succession of the Meadfoot beds on the west of the Dart seems to be as follows in descending order:—

1. * Dark slates with hard grey and brown grits and brown friable fossiliferous matter.
2. Dark grey slates with impersistent partly calcareous siltstone bands, films and lenticles.
3. Similar slates with volcanic seams impersistent.
4. Reddish slates and red and greenish sandstones, which may be continued by greenish grey sandy shales and banded mudstone westward from Cotterbury.
5. Dark grey slates with arenaceous films or gritty shales, possibly a repetition of the beds west of Cotterbury.

* These are, no doubt, on the horizon of the fossiliferous Meadfoot bed disclosed in the New Drive (south of Hope Farm) in the Torquay promontory.

These arenaceous shales (5) are of frequent occurrence in the south-western part of the district. They form a common type met with near East Allington and in the Kingsbridge district. The laminæ are sufficiently coherent to enable the rock to be quarried out in large thick slabs (used for stiles, boundary fences, lidstones, &c.). This type is well shown between Bowbridge and Forder (south of Blackawton). Dark brown compressed friable material, apparently fossiliferous calcareous residue, is noticeable here and there in the slates between Newton Cross and Ford Corn Mill and on the south side of Millcombe. I think that the calcareous beds in Southdown Cliff are on or near the horizon of the limestone bands south of Lower Noss Point. These are continued by slates with shaly limestone lenticles and decomposed friable fossiliferous bands along Old Mill Creek. The westerly continuation of this horizon is shown by exposures of fossiliferous slates in quarries (on the 6-in. map) at West Norton Wood, between West Norton Wood and Bugford Lane End, and by the stream to the west of Bugford Lane End, near Lower Wadstray and at Lower Wadstray, where red-brown very fossiliferous friable matter is present. These all correspond to (2) in the above sequence. The following are apparently higher in the series and correspond to (1) in the sequence. Near Hole Farm, south of Bosomzeal, slates with hard grey grits and brown friable bands containing *Homalonotus* and Gasteropods are exposed in quarries near the top of the Meadfoot beds. Fragments from the same horizon south of Capton Cross contain *Homalonotus armatus*?. North of Wood, west of Blackawton, Brachiopods, including *Chonetes* and *Rensselæria*?, are met with in brown friable grit which, with some hard grit beds in the vicinity, have been included in the Meadfoot series. North-east of Chipton, by the lane from Downton Cross to Old Mill, fossils resembling *Chonetes* and *Tentaculites* were found in red slates; these may, however, belong to the Staddon grits, as their junction beds with the Meadfoot group may be repeated by plication near Chipton.

Typical Meadfoot beds, probably on the same horizon as at Hole Farm, occur at Higher Noss Point, and contain hard brown fossiliferous beds. There are very fossiliferous lenticles, apparently with casts of Gasteropods, in the slates by the road between Noss Plantation and Furland. The grits just south of Furland may also belong to the upper part of the Meadfoot series. Between Furland and South Down Cliff the horizon cannot be continuously traced, and there are many faults, none of which can be located with certainty. Between Guzzle Down and Raddicombe there must be more than one fault to account for the absence of the Staddon grits and the junction of Eifelian slates and Meadfoot beds which cannot be approximately located. The upper beds of the Meadfoot group are apparently brought in by changing strikes between Forder and Southdown. In a brown grit surface stone north of Forder, at 25 chains east of Raddicombe Barn (see 6-in. map), fragments of *Homalonotus* and *Tentaculites* were found. Towards Southdown Cliff the relations of

the Meadfoot and Staddon beds are not clear. The thin lenticular limestone bands and brown and yellow friable fossiliferous seams in the slates south of Lower Noss Point contain *Spirifera*, either *Sp. primæva* or *Sp. Decheni*, according to Mr. Newton. Near Old Rock Inn the slates contain brown friable matter. In a quarry in the irregular patch of grit south of Hoodown there are brown earthy bands evidently fossiliferous. A gritty micaceous shale in this quarry exhibits markings (*Chondrites*?) also found in a dark slate at Long Sands. In Nethway Quarry (west of Woodhuish) dark grey slates with decomposed fossiliferous matter contain *Zaphrentis*, *Fenestella*, and crinoids. Near Woodhuish limestone lenticles, brown filmy fossiliferous bands, and gritty intercalations are met with in the slates. They are the prolongation of the calcareous horizons so well exposed in the coast section on the south of Crabrock Point. There is every reason for regarding these horizons as a repetition of the red beds with (Monticuliporoid ?) limestone bands and fossiliferous grits containing Brachiopods, which bound the Dartmouth slates between Scabbacombe Head and Scabbacombe Sands. The same horizon occurs at Kingswear. Casts of fossils, including *Rhynchonella daleidensis* ?, are met with in brown arenaceous shaly beds by Waterhead Creek, west of Waterhead Mill.

Staddon Grits.—Between Southdown Cliffs and Raddicombe the relations of these beds to the Middle Devonian rocks are everywhere obscured by fault. From Guzzle Down to the Dart, although the junction with the Eifelian slates appears to be a natural one, the exposures are insufficient. West of the Dart the junction is evidently faulted in several places near Kingston, and near Newhouse and Bickleigh there are no clear exposures. Around Higher Tideford grey slates, partly gritty and with grey grits, nowhere properly exposed, render the junction exceedingly uncertain. At Capton Wood,* south of Barberry Water Mill (on the 6-inch Map) grey slates occur in mass. There are also grey slates and mudstones between Allaleigh and Halwell Camp, and near Bosomzeal. There is no means of proving whether these slates belong to the Lower Devonian or to Middle Devonian (Eifelian) brought in by a syncline.

With these and similar local exceptions, the main outcrop of the Staddon group exhibits the usual characteristics of greenish, red and lilac grits and sandstones, often shaly, with the red speckled quartzose Warberry grit, and other local types, here and there. No fossils have been found in the main outcrop, although in the irregular synclinal tongue, between Capton and Blackawton, they have been detected in several places,† viz—in red speckled quartzose grits north-east and north of Hemborough Post, south of Stone Farm, where *Tentaculites* and Brachiopods (*Chonetes* ?) occur. In a quarry in purple and red grits east of

* West of Kingston.

† In the prolongation of the grit near Ritson westward into the adjoining map (349) *Bellerophon trilobatus* and *Homalonotus* occur, south-south-east of Stanboro House, south of Halwell. The same fossils have been found on Lincombe Hill, Torquay.

Quarry Head (between Oldstone and Blackawton) numerous badly preserved fossils are obtainable, including Gasteropods (*Pleurotomaria* ?). Near this, on the west side of Quarryhead Wood, white, red-speckled grit is exposed in quarries and contains badly preserved fossils (*Rensselaria* ?). No fossils were obtained in this group between the Dart and Guzzle Down. Near Raddicombe (on south-east side) a grit fragment was found, apparently belonging to this group, and containing *Tentaculites scalaris* ?.

The Paignton Anticline.

On the north of Saltern Cove the Lower Devonian rocks consist of red slates with beds of quartz-veined grit overlain by New Red breccia; they are separated from red slaty Upper Devonian mudstones (The Büdesheim beds) by a reversed fault or thrust. The position of the fault is obscured by the similarity in colour, where grits are not evidenced; but it is certainly shifted northward by cross faults to Clennon Hill, whence it continues westward, frequently shifted by cross faults, throwing limestones and volcanic rocks down on the south, and cutting out the Eifelian slates completely. Toward Aish, washes from the high ground obscure the evidences of its position. Between Aish and Berry Park Lodge, Eifelian slates appear at Longcombe on the west of the fault boundary; they may also underlie the limestone of Lomentor Copse in a faulted tongue which indents the Lower Devonian.

A detached faulted mass of Lower Devonian is seen at Byrch Clump, on the 6-inch map; between it and Longcombe there are several limestone patches, some of which appear to be thrust over Lower Devonian grits and shales which occupy an irregularly faulted tract between the limestones on the west of the main fault boundary. Further north the main boundary separates Eifelian slates from the Lower Devonian. There is a strip of red slates, west of Borton Pines, which may belong to either group. There are no junction exposures, so that it is impossible to tell whether the boundary is anywhere unfaulted. Near Wildwood the northern boundary is a fault, and further east its position is rendered extremely uncertain through the prevalent lilac and red tints in the slates south of the Marldon limestone in proximity to the New Red rocks. This uncertainty is accentuated by the occurrence of *Pleurodictyum* in the red slates near Westerland House, by the presence of grey slates of the Berry Park type, apparently in faulted association with the red slates west of Westerland House and at Lower Westerland, by the prevalence of red slates in the Lower Devonian on the northern slope of Beacon Hill and south of Churscombe.

From Churscombe eastward the Lower Devonian rocks are partly in faulted, partly in natural unconformable relation with the New Red rocks. The prevalent red colouring in the Devonian rocks of the Paignton anticline renders the detection of the Meadfoot beds, as a separate series, impossible. That they are brought up by some of the numerous faults, and in

anticlines, is certain. An abortive attempt was made to trace this group between Shortdown and Livermead. A small quarry (on the 6-inch map near Broomball Plantation), north-east of Windmill Hill Clump, displays slates and slaty grits exhibiting the characteristics of the Meadfoot beds. Fossils were obtained in a fine-grained lilac-brown grit in this quarry, and were kindly identified by Messrs. Gosselet and Barrois (unless otherwise stated) as follows :—

Pleurodictyum problematicum.	Rhynchonella daleidensis (identified by Prof. Kayser).
Homalonotus gigas.	
Chonetes sarcinulata.	—— hexatoma (near to Rh. daleidensis).
—— semiradiata.	

A *Leptæna* resembling *L. spathulata* was found in a grit fragment near Broomball Plantation on the west. These fossils point to the Lower Coblenzian age of the rocks.

In the red shaly beds with grit bands, exposed in Saltern Cove railway-cutting, *Chonetes sordida* and *Pleurodictyum problematicum* were found, besides the following which Davidson thought he could recognize amongst the fossils obtained from the cutting by the Rev. G. F. Whidborne :—

Leptæna looensis.	Rhynchonella pengellyana.
Orthotetes hipparionyx.	Spirifera lævicosta.

The natural inference from the above is, that these beds correspond to the fossiliferous rocks of Looe. This is, as far as I know, with one exception* the only recorded discovery of *Rhynchonella pengellyana* in Devon, the original specimen having been determined from the Looe rocks by Davidson. It is given by Sandberger as a distinctly Gedinnien species, and is, at any rate, strongly suggestive of the inclusion of lower horizons than the Lower Coblenzian in the Meadfoot series. Between the New Red outliers, south of Goodrington Sands, red slates, very irregularly associated with grit beds and much plicated, yielded *Tentaculites*, *Orthoceras*, *Spirifera*, *Zaphrentis*, and *Pleurodictyum*. Between Paignton and Torquay, near Hollowcombe Lake, north of Preston, the red slates and grits contain fossils too imperfect for identification. In this neighbourhood slates seem to underlie grits and sandstones, becoming intercalated with grit beds and resting on grits near Shortdown. *Spirophyton*† was found in red shaly grits near Shortdown. Red slates with grit by Seaway Lane, Cockington, yielded *Homalonotus*. In red grit fragments ploughed up on the margin of Staddon Plantation, Cockington, *Pterinæa* and a good example of *Spirifera hysterica*† were obtained.

On Paignton Windmill Hill, red slates and grits, cropping out by a hedge in a field near Ramshill Cross, furnished *Pleuro-*

* Viz., *Rh. pengellyana ?* amongst Champernowne's fossils from New Cut, Torquay, identified by Etheridge, with doubt. *Geol. Mag.*, Nov. 1881, p. 490.

† Identified by Messrs. Gosselet and Barrois.

dictyum and *Homalonotus* ?.* On Beacon Hill, south of Westerland House, amongst the numerous grit fragments ploughed up, brown fossiliferous stones yielded *Homalonotus*, *Nucula* (near to *N. kahlebergensis*, Bausch., perhaps *Palæoneilo* of the Coblenzian), and indeterminable fragments of Gasteropods and Lamellibranchs. By the high road, south of Churscombe, 15 chains from the Ship Inn, *Spirifera speciosa*, *Streptorhynchus*, *Orthis*, and *Pleurodictyum problematicum* were obtained in rocks very similar to those in the Saltern Cove Railway Cutting. In a quarry by the road from Livermead to Cockington, traces of Brachiopods were noticed in red grit with numerous included fragments of shale.

The Torquay Anticline.

Better opportunities for the study of the characters of the Staddon and Meadfoot groups, and for obtaining fossils in them, are afforded in the Torquay promontory than elsewhere in this area, owing to many exposures in road cuttings supplementing the coast sections.

The structure is a complex anticline, cut up and displaced by innumerable faults and thrusts, and the strata are moreover exceedingly contorted. From Warberry Hill the Lower Devonian (Staddon grits) extends westward in a strip bounded by faults, one of which is well shown in Market Street, from the Western Hospital to Mudges Copse (Thurlow Road), where it is cut off by a fault. A bifurcation occupies the high ground between Warberry Hill and Babbacombe Church. If the main boundary is anywhere in unfaulted relation to Eifelian slates it would be so on the south of Babbacombe Church, but there are no junction sections. North of the Western Hospital some red and greenish slates and shales are exposed by a new road; they are open to the same doubt as the red slates round Westerland House, as to whether they are Lower Devonian or Eifelian.

Between the Warberry and Lincombe† Hills there are no exposures beyond a small mass of shattered limestone by Lower Warberry Road, just inside the grounds of Wellswood House, and indications of slates north-east of it, which may be Eifelian. It is not improbable that the grits of Warberry Hill are separated from those of Lincombe Hill by a synclinal tract of faulted Middle Devonian rocks; if not, the connection would be on the south of the patch of limestone mentioned above, *i.e.* between Lower Warberry Road, Erith House, and the faulted boundary of the Braddons Hill and Lisburn Crescent limestones.

Behind Hesketh Crescent there is a fault junction between the Middle and Lower Devonian; it is nowhere visible, but from very slight exposures of Lower Devonian rocks in Lower Lincombe Road and elsewhere, it appears to run in the direction shown on the map, toward Apsley House. The grits of Lin-

* Identified by Messrs. Gosselet and Barrois.

† Lincombe Hill is called Oxlea Hill on the map.

combe Hill are faulted against Middle Devonian limestones on the north, the fault boundary traced eastward cuts off the Black Head Diabase against Lower Devonian at Smugglers' Cove.

At Hope's Nose the Lower Devonian is separated from the Middle by a series of faults; but in the bay on the west of the Raised Beach, on the southern shore of the promontory, the uppermost grit beds of the Lower Devonian are visible at the base of a broken cliff composed of Eifelian slates, capped by irregular calcareous slates and slaty or shaly limestone. This section* commences at a well-marked fault, hading east and throwing down the limestones which form the southern horn of the promontory. Near this, proceeding westward, the lower part of the section is composed of dark slates or slaty shales, which are the basement beds of the Eifelian. In the lower parts of the cliff, a mass of grit, 10 feet thick, in beds of from two inches to two feet in thickness, terminates abruptly in the dark slates. Although in apparent horizontal intercalation, the grits are evidently sharply folded and connected with Lower Devonian grits on the beach; the connection being obscured by tumbled blocks of limestone. The grits are hard, fine-grained and quartzose, of pale grey or reddish grey colour, and with whitish surfaces, studded here and there with small black, glistening, argillaceous filmy patches. In the beach reefs the grits are in irregularly contorted association with the dark slates; they are laminated, and interlaminated with shaly films, in places. On the bed surfaces changes in colour, from grey to red with green mottling, are noticeable. Fossil casts are plentiful on some of the surfaces, but they are very badly preserved and impossible to extract. *Loxonema* and *Pleurodictyum problematicum* were recognised. Toward the end of the beach a sharp easterly tilt is observable in the Eifelian slates above, and the grits rise from the beach to a height of about 40 feet in the cliff. This sudden rise of the grits is probably accompanied by a fault, and they are cut off on the west by a fault, concealed by *débris* in a small gulley which descends to the beach, at its western end.

On the opposite side of the gulley the cliffs are formed of characteristic Meadfoot beds, consisting of dark slates with fossiliferous seams (in which *Zaphrentoid* corals are conspicuous) and brown-weathered even grit beds showing local contortion and disturbance. These beds form a strong contrast to the thick beds of grey grit on the east side of the gulley.

This section was noted by the late E.B. Tawney thus:†—"On the other side of Hope's Nose tongue of land we have merely the top part . . . the lower part is cut off by a fault which brings grey and red grits against beds of the Meadfoot series." In the red and grey (Eifelian) shales above the red grits he obtained *Favosites Goldfussi* and *Cyathophyllum*; in the red grits *Ten-*

* See fig 6, on p. 51.

† *Trans. Devon. Assoc.* Vol. 4, p. 293, 1870.

taculites scalaris, *Homalonotus*, *Streptorhynchus gigas*, and other fossils, mostly Lamellibranchs.

If these fossils are undoubtedly from the uppermost grit beds of the Lower Devonian and not from the grits in Smugglers' Cove the presence of *Streptorhynchus gigas*—which occurs in the Onychien quartzite and Rhipidophyllen Schiefer—(the lowest horizons of the Gedinnien in Nassau), according to Sandberger,* and does not go up—is remarkable.

As there are no Eifelian slates on the north coast between Smugglers' Cove and Hope's Nose, the fault in the gulley on the south coast alone, or in conjunction with cross dislocations, in some undiscoverable way, cuts off the Eifelian slate tract between the north and south shores of the promontory. The uppermost beds of the Lower Devonian are also exposed in the exceedingly faulted tract bounding Redgate Beach (*see* Fig. 3 p. 13). Here tough broken fine grits of a chocolate red colour, in one spot exposed to a depth of eight feet, occur under red shales with grit bands, and are overlain by dark slates or shales, evidently Eifelian. The extension of both is effectually concealed by talus and limestone blocks; no fossils were found. It is impossible to correlate these beds with any special horizons in the Lincombe and Warberry grits. The tendency of the evidence in this, as in the Paignton and Southern district, is to prove that the character of the junction beds of the Lower Devonian with the Eifelian is variable, sometimes formed by grits, sometimes by slates or shales with intercalated grits, or grits and grit shales with intercalated shales or slates.

The boundary of the Staddon and Meadfoot groups is not a very reliable one to judge from the two sections in which it is exposed—viz. at the bend in the New Cut drive (north-west of Kilmorey) and by the New drive (south-east of Hope Farm and north-east of Kilmorey). In the New Cut the red slaty beds and grits become buff, mottled with purple, and seem to pass more or less horizontally into grey slates with bands of grit. There may, however, be a fault at the bend in the New Cut running towards Lisburn Crescent. The red beds of Lincombe Hill terminate at Torcello, Higher Lincombe road, in the manner shown on the map; but, between their termination and the faulted limestone of Apsley House, green grits (or sandstones) and grey slates are evidenced in places in Lower Woodbury Road and by the steps leading to it from Higher Erith Road, and in and between Lower and Middle Lincombe Road. These may be the upper or lower beds of the Staddon group. Greenish grits and grey slates are also faulted against the Asheldon Copse limestone by the Babbacombe road. On the slope below the New Cut, above Hesketh Crescent, greenish and grey grits are associated with dark grey slates.

In the New Drive, west of Hope Cove (the cove south of Smugglers' Cove) the peroxidated grits and slaty beds are shown to change colour and to become brown grits associated with grey

* *Jahrb. d. Nassau Ver. f. Nat.* Jahrg. 42.

slaty shales. Near this the fault shown in Hope Cove, and noted in Tawney's section, crosses the road, and for ten chains in a south-easterly direction the rocks exposed by the road would be classed as Meadfoot beds. There appear to be at least two fossiliferous horizons in them (perhaps roughly corresponding to those of Hole Farm and Higher Noss Point in the southern district). These beds are succeeded by dull green grits with occasional flakes of shale,* and hard grits, often flaggy, which are cut off by a nearly north and south fault along the crags overlooking the Hope's Nose promontory.

These grits, if lithological character is worth anything, belong to the Staddon group; indeed, they may be the upper beds of that series thrust over the Meadfoot beds. They occupy the highest ground between Kilmorey and Hope's Nose, on which, as their persistence is very doubtful, they are indicated by two patches on the map. The westernmost of these patches is evidently a very thin capping of flaggy greenish grit, occasionally red, judging by surface stones on the hill above Kilmorey. Traces of fossils including *Atrypa*, *Rhynchonella*, *Chonetes* and *Spirifera cultrijugata* were obtained. There is doubt about the last named owing to the imperfection of the specimen. Greenish sandstones associated with or overlying grey slaty mudstone and dipping in northerly and north-westerly directions are exposed in quarries near Kilmorey on the east. In stones in one of these quarries *Homalonotus*, *Chonetes*, *Spirifera* and *Pleurodictyum* were noticed. This westernmost patch has every appearance of an outlier, but between it and the easternmost mass there are hard and soft grey slates which are more or less fossiliferous, and as far as character goes might be Eifelian.

These slates contain *Pleurodictyum*, and *Cornulites* (identified by Mr. Whidborne) was also found in them. The green sandstones of the larger patch seem to dip under them near its south-eastern boundary. The upper parts of the cliffs bounding this tract are also suggestive of a newer slaty series overthrust on an older (the Meadfoot beds); the relations of the rocks between Kilmorey and the Eifelian of Hope's Nose are therefore exceedingly doubtful. The cliffs under Kilmorey are characteristic Meadfoot beds. In the same series from here to the gulley fault, west of Hope's Nose Raised Beach, there are many faults; one of these is well shown (marked by fault rock) in the cove on the east side of the southernmost point on the coast. It cuts off a mass of red grit forming the end of the point, apparently the axis of a uniclinal plication. The cliffs of the cove in the lower part are composed of dark grey, partly siliceous, slates, with fucoidal markings and *Chondrites*?† and traces of

* Lithologically identical with green grit in the Staddon grits near Plymouth.

† Similar to those in the quarry south of Hoodown, and in dark slate at Long Sands. A gritty shale with irregular surface markings, fucoidal? noticed here has been observed on the Thurlestone Coast and in many Lower Devonian sections in Devon and Cornwall.

Gasteropods (*Pleurotomaria* ?) and other organisms. No absolute decision as to the position of these beds can be arrived at owing to the zig-zag contortions accompanied by thrusts (or axial displacements) and traversed by faults, which are everywhere met with; but the probability of their equivalence to the slates in contact with the grit of Long Sands may be hinted.

On the north coast, between Smugglers' Cove and Hope's Nose, a continuous section is visible; but the upper parts of the cliff slopes are almost invariably concealed by undergrowth, grass, and talus. The fault at Smugglers' Cove is marked by a deep depression separating the Black Head diabase, on the north, from red Lower Devonian rocks on the south. The latter consist of red slaty shales with thin grit beds, and intensely peroxidated hard fossiliferous bands, on pale lilac and greenish slaty shales, with hard massive grit beds (often interlaced with quartz veins) in the lower part of the cliff. On the beach thin beds of compact grit separate the above from grey buff-banded slaty rocks, which crop out near the fault, and were noted by Tawney as Meadfoot beds. In the next Cove (Hope Cove), through a southerly deflection in the strike, the beds above the thick grits occupy the lower part of the cliff; an oblique cleavage not affecting the grit beds is apparent. The following descending sequence, in a thickness of 8 feet, gives a fair sample of the section:—

Thin brown-red and green grit bed.
Red slaty shales.
Red and greenish slaty shales with impersistent bands of peroxidated fossiliferous grit with green shaly films.*
Grit, partly compact.

These beds are exposed for 24 yards in the cove, but beyond this the base of the section is concealed by tumbled blocks of red and grey rocks for 34 yards. A colour change probably takes place in this interval. Greyish and brown purple-stained grits with grey slates are then encountered, dipping south at 30°. The fault, noticed by Tawney, here traverses the section, bringing on a sharply folded axis (with lower limb horizontal) of brown and grey grits associated with knubbly irregular slates, which may be a repetition of those in the beach reefs of Smugglers' Cove. The partly decomposed fossiliferous slaty limestone† bed occurs at the base of the folded mass, but cannot be traced upward, as the whole is cut off by a tributary fault, or slide, joining the main dislocation above, and bringing on 10 feet of brown and grey hard grit beds (with purple surface mottling). These grits form the southern horn of Hope Cove, and dip under the following, in upward succession:—6 to 7 feet of grey slates

* This character, already referred to as common to the Hangman grit series, the Looe grits, etc., was noted by Champernowne (*Geol. Mag.* Nov. 1881, p. 488) as characterising Ludlow rocks in the Usk district.

† *Zaphrentis* is recognisable, also black patches (fish traces ?). The latter are noticeable in similar rocks in the Meadfoot beds—at 23 chains west of Kilmorey, in Crownhill Bay, south of Plymouth (near Boveysand Bay), &c.

with hard thin brown shaly grit—an irregular bed of hard grit—20 to 25 feet of dark shales or slates, with hard thin brown weathered grit bands—a lenticular fossiliferous band. Above this the rocks may be the same as those in Hope Cove. The coast runs for about 13 chains from this, more or less coincidently with the strike. Grey slates with brown grits and thin grit bands are shown in sharp zig-zag plications, determining the surfaces of rock shelves at the base of the cliff, and occasionally broken by small faults. In places the section is red in the vicinity of joints or faults. For the remaining 9 chains the dips are often easterly. In the coves the grits and slates are red-stained for about 2 chains (*d* in Tawney's section). Beyond this, irregular dark grey slates, crossed at intervals by brown grits and partly calcareous fossiliferous bands, are in faulted junction with the Middle Devonian limestone of Hope's Nose Quarry.

This section is inconclusive as to the boundary between the Staddon grits and Meadfoot series. It proves that absolute reliance cannot be placed on colour distinction, and without that guide one cannot say in which group the peroxidated beds of Smugglers' and Hope Coves should be included.

In the following notes on the fossil localities in rocks classed as Meadfoot beds, and in rocks classed as Staddon grits, this separation is therefore often arbitrary.

Meadfoot Beds.

In decomposed fossiliferous bands and siliceous limestone, traversing the dark slates near their faulted junction with the limestone of Hope's Nose Quarry, the following fossils were obtained:—

Pleurodictyum problematicum.
Zaphrentis.
Homalonotus Rœmeri?
Spirifera primæva.
Strophomena rhomboidalis (var. *analoga*, according to Whidborne).

At from 10 to 11 chains due south of Hope Farm, on the edge of a bramble brake, very fossiliferous decomposed brown beds and tough orange-brown bands are met with in grey slates. These beds can be more or less continuously traced along the contour to the New Drive, where they contain a bed of siliceous limestone, so that there is here a fossiliferous zone or zones extending continuously for a quarter of a mile. The fossiliferous beds are associated with irregular knubbly slates (of the Meadfoot and Lynton type) and beds of hard brown grit, in which remains (spined plates, portions of glabella, etc.) of *Homalonotus* are plentiful.

The following fossils were obtained from the beds in the New Drive:—

Spirophyton.
Homalonotus armatus? (plentiful).
Chonetes (plentiful).
Leptæna laticosta (Tropidoleptus rhenanus)—plentiful.
Orthotetes hipparionyx.
Rensselæria strigiceps.

Rhynchonella (near to pugnus).	Ctenodonta concentrica ?
Spirifera cf. lævicosta.	Pterinæa.
— microptera.	Tentaculites scalaris.

The following were found on the edge of the bramble brake:—

Homalonotus (comparatively scarce).	Rhynchonella (large).
	— sp
Chonetes.	Spirifera (large).
Leptæna laticosta (plentiful).	Pterinæa.
Orthis hipparionyx.	Tentaculites.

This horizon is no doubt shifted by fault on the east; on the west it cannot be traced on the slope toward Kilmorey, where we should expect to find it below the western grit patch from the parallelism it exhibits to the northern boundary of the eastern grit mass, assuming these to be ordinary outliers. The cliffs and beach reefs under Kilmorey are composed of the irregular dark slates with hard grit beds and decomposed fossil bands characteristic of the Meadfoot series. Here *Pleurodictyum problematicum* was found. Dr. Kayser's* list from this spot is as follows:—

Zaphrentis oolithica (determined by Dr. Frech).	Spirifera hysterica.
	—— paradoxa.
Rhynchonella daleidensis.	Strophomena cf. Murchisoni.
Chonetes sarcinulata.	Pterinæa costata.

Mr. Whidborne† mentions the occurrence of *Strophalosia productoides* "in the *Pleurodictyum* beds at Meadfoot." Pengelly‡ recorded the discovery of a single scale of *Phillolepis concentricus* in coarse gritty slates at the base of the cliff under Kilmorey, and of a rather doubtful scale of *Holoptychius* from Meadfoot Sands. Salter in his monograph (Pal. Soc., 1865) gives Meadfoot Sands as the locality for *Homalonotus elongatus* (a species founded on the discovery of a tail). Phillips records (Pal. Foss.) *Orthoceras tentacularis, Spirifera costata, Orthis granulosa, O. plicata* and *Avicula anisota* from Meadfoot. Meadfoot Sands is too indefinite a term, as both Eifelian slates and Meadfoot beds are present in the cliffs on the west and on the east of Hesketh Crescent, respectively. The slates of doubtful character east of Kilmorey seem to overlie the green sandstones of the eastern outlier. On the southern border of the copses north-east of Kilmorey they contain many crinoid fragments and badly preserved fossils, amongst which were recognised the following:—

Pleurodictyum.	Spirifera lævicosta ?
Zaphrentis.	— speciosa.
Cornulites sp. (three specimens identified by Whidborne).	Streptorhynchus.

* *Neues Jahrb. für Mineralogie*, &c., 1889. Bd. 1, p. 188.

† Pal. Soc. 1893, p. 156.

‡ *Trans. Devon. Assoc.* for 1868. History of the discovery of fossil fish, and *Ibid.* for 1874 in Notes on Recent Notices, &c., part 1.

By the easternmost copse, *Rhynchonella* and *Pleurodictyum* were found. The possibility of these slates being Eifelian and thrust over Meadfoot beds has been before referred to. They resemble slates included in the Eifelian of Ellacombe and near Warberry Mount.

Staddon Grits.

The exposures on Warberry Hill are slight, and this may be the reason why so few fossils have been obtained. The faulted strip of red grits and shales between the Western Hospital and Thurlow Road is better exposed, but no fossils have been obtained. In the wood near Warberry Reservoir red slates are exposed. If unfaulted, towards Babbacombe Church greenish slates at the base of the Eifelian are succeeded by red shales with beds of grit, over red grits presenting many examples of the white quartzose red-speckled variety. Amongst the materials turned out in the excavation of Warberry Reservoir, fragments of red-speckled grit containing *Tentaculites*, a cast of *Spirifera* (?) and *Beyrichia* were recently obtained; previously *Beyrichia wilckensiana* had been identified by Professor Rupert Jones in a fragment from this locality. If the green grits by the Babbacombe Road (near Asheldon Copse) and between Lincombe Hill and the Apsley House limestone were peroxidated, it is questionable if they could be distinguished from the red and red-speckled grits of Warberry Hill.

The reason the term given to this series by Champernowne "Warberry, Lincombe and Smugglers' Cove grits" has not been adopted, is, apart from its length, to allow for the probability of the Lincombe and Smugglers' Cove grits being in part stained Meadfoot beds, although the Warberry Hill beds are not open to this probability, as far as one can judge by the evidence.

In the field in which the round copse on the northern part of the summit of Lincombe Hill is situated, fragments of red, buff and red-speckled grit (and occasionally of banded rock of the Pigshill Wood type) are ploughed up. Some of these are fossiliferous, containing *Homalonotus, Chonetes, Orthis, Pentamerus* and *Pleurotomaria*. The following were specifically identified:

Pleurodictyum problematicum.
Bellerophon compressus.

On the south side of the copse grey and greenish slates and grits prevail. Further south near the 400-foot contour south of St. Raphael's Home, in pale buff, pale grey, and green tough hard and brittle grit stones, the following were obtained:—

Leptæna laticosta.
Spirifera primæva?
— sp.
Streptorhynchus.
Bellerophon trilobatus.
Tentaculites multiformis.

By the New Cut, within a hundred yards east of the spot where the red beds change colour, Champernowne* obtained

* *Geol. Mag.*, Nov., 1881, p. 487, &c.

the *Homalonotus* named *H. Champernownei* by Dr. Woodward, besides fragments probably representing two other species. Some of his fossils were identified by Mr. Etheridge. The rock is described as "red finely-sandy or silty beds, interstratified with grits" and "traversed by a coarse cleavage dipping south, which usually ignores the hard grit bands." The following, not included amongst Mr. Etheridge's identification, are also given by Champernowne :—

Tentaculites.	Cypricardites ?
Chonetes sordida ("often crowded in certain layers.")	Myalina. (Small)

Dr. Woodward's identifications :—

Homalonotus Champernownei.	Homalonotus sp.

Mr. Etheridge's identifications are :—

Petraia.	Streptorhynchus umbraculum.
Pleurodictyum problematicum.	Pullastra.
Chonetes.	Holopella or Loxonema sp.
Orthis.	Cyrtoceras.
Rhynchonella pengellyana ?	Orthoceras.
Spirifera cultrijugata.	

The following were obtained during the early stages of the survey in 1888 in the New Cut, and in stones on the slope below :—

Pleurodictyum problematicum.	Tentaculites.
Avicula anisota, *Phil.*	Orthoceras.

Obtained in 1900 :—

Homalonotus armatus ?	Orthotetes hipparionyx.
Chonetes sordida ?	Spirifera.
Leptæna laticosta ?	

There is an appearance of a syncline in the red beds by the New Cut, noticed by Champernowne. Though the structure of Torquay is too complex to attach very much importance to it, it is consistent with the actual continuation of the red beds to Hope Farm and Smugglers' Cove. Near Hope Farm lilac-red and grey-lilac purple-mottled grits and slaty beds are exposed by the New Drive. The red-speckled grit type also occurs here, and a fossil resembling *Leptæna looensis* was found in it. At the bend in the new drive between Hope Farm and Hope Cove there is a contortion in the red grits, apparently in the vicinity of a fault.

In the hard peroxidated bands of Smugglers' Cove many fossils are to be seen, but it is extremely difficult to develop them sufficiently for specific identification. Tawney* considered the red beds of Smugglers' Cove to be about 150 feet thick; this estimate would be nearly correct if we could be certain that the cliffs afforded a direct succession, but the probability of zig-zag

* *Trans. Devon. Assoc.*, vol. 4, p. 292, 1870.

plication carrying the lower beds upward is much too strong to be overlooked. Champernowne obtained, "at Smugglers' Cove, with Mr. Lee," .... in reddish schistose masses slipped from the cliff, many casts of *Orthis*, *Spirifera*, and *Leptæna laticosta*. The bed effervesces, being an impure limestone." Tawney commented on the occurrence of *Tentaculites* and of *Cypricardiæ* in the red beds in Smugglers' and Hope Coves, and mentioned the discovery of *Pleurodictyum problematicum* in the faulted grey grits of the Meadfoot series in Hope Cove. According to Champernowne,* "Tawney's Smugglers' Cove list includes *Homalonotus* n. sp. (most like *H. Johannis* from the Wenlock beds)"; but this list is given in connection with the section on the southern coast of Hope's Nose promontory, and just after mention of fossils in Middle Devonian slates above the red grits. Although this list has already been given as obtained from the uppermost beds of the Lower Devonian, the possibility that the red grits were meant to include the Smugglers' Cove beds is suggested by Champernowne's remark. Our lists from the red beds of Smugglers' Cove and Hope Cove are as follow:—

Smugglers' Cove:	Hope Cove:
Pleurodictyum.	Pleurodictyum.
Chonetes plebeia.	Crinoids.
Edmondia.	Cyrtina or Spirferina.
Macrochilina.	Leptæna laticosta.
Pleurotomaria.	Spirifera.

Tawney's list, presumably from the uppermost beds of the Warberry group, West of Hope's Nose Raised Beach, is as follows:—

Homalonotus, n. sp. (most like H. Johannis from the Wenlock beds).	Cypricardia lamellosa?
Orthis arcuata?	Modiolopsis?
— (like Berthoisii).	Pterinæa ventricosa?
Streptorhynchus gigas.	— (like bifida or anisota).
Cardiomorpha.	Natica.
Ctenodonta.	Tentaculites scalaris (apparently most abundant).

Obtained by the Survey:—

Pleurodictyum problematicum.	Loxonema.

On the whole the Lower Devonian succession in Sheet 350 is rendered very unsatisfactory by the disturbed relations of the rocks and the utterly unsatisfactory character of the palæontological evidence.

In the Torquay and Paignton areas the main question is whether the Looe beds are represented or not. This is a purely palæontological question, for no objection on lithological or stratigraphical grounds can be urged. It seems to be answered in the affirmative by the identification of such fossils as *Spirifera primæva*, *Streptorhynchus gigas*, *Rhynchonella pengellyana* and *Orthotetes hipparionyx*.

* *Geol. Mag.*, Nov. 1881, p. 488.

The discovery of specifically recognizable fossils in the southern part of the area is necessary to enable one to piece together the more broken succession of Torquay.

The records of the occurrence of *Spirifera cultrijugata* are meagre and unsatisfactory *Pleurodictyum* is of no value whatever. The remains of *Homalonotus* are so numerous in the Torquay promontory that there is considerable scope for research as regards that genus alone. In fact, in bringing this chapter to a close, one can only deplore the paucity of specifically identified fossils, due to their bad state of preservation, but still more to the need for special search, even in unpromising localities, by which alone doubts as to the absolute position of certain rocks in the series could be satisfactorily solved. Whatever light may be cast on the Lower Devonian succession by such researches, it will be seen that they are minor points, and do not affect the general structure and disposition of the strata as set forth here.

Evidences of Contemporaneous Vulcanicity.

No igneous rocks have been detected in the Lower Devonian rocks of the Torquay and Paignton areas. In the main outcrop isolated traces of igneous rock, or of decomposed material probably of igneous origin, have been found in different places, and apparently in different parts of the series. The chief indications and those which point to horizons of vulcanicity are to be found in the Meadfoot beds from Sandquay Quarry westward to Paddlelake (east of Blackawton), and in the Dartmouth slate area along the southern shores of the Kingswear promontory and from the mouth of the Dart to the south-west margin of the map.

At about 20 chains north of the Coastguard Station at Man Sands a sheared igneous band, two feet in thickness, is noticeable in the cliffs in lilac and grey slates. Igneous rocks similar to those of the Torcross coast occur in the slates between Long Sands and Crabrock Point. In the valley between Nethway House and Woodhuish there are signs of igneous rocks in grey and bluish slates. Further west between Boohay and Waterhead Brake there is an irregular mass of very hard bluish or dark grey brown-weathered rock, probably an intrusive diabase. By the Dart, between Higher and Lower Noss Points two or three feet of igneous (probably volcanic) rock occurs in bluish grey slates.

On the shores of Old Mill Creek at Hermitage Castle, and by the tributary creeks near Great Copse and Rough Hole Barn, there are thin bands of volcanic rocks in the slates. By the Dart, at Lower Kilngate north of Old Mill Creek, a few feet of peroxidated materials, probably decomposed igneous rock, occurs in the Staddon beds. With this exception, the traces of igneous rock mentioned occur in the Meadfoot beds, and may possibly belong to the same series repeated by folds.

Further west there appear to be volcanic bands in the slates near their junction with the Staddon grits south-east of Higher Wadstray.

In Sandquay Quarry about thirty feet of quartz-veined porphyritic diabase occurs in grey sericitic-looking slates. At the Gymnasium north of the Quarry there appears to be a volcanic tuff band in the slates. The Sandquay rock cannot be traced more than a quarter of a mile westward, but between Mount Boone Farm and Norton there are seven masses of igneous rock, two of which resemble the Sandquay rock, and three are aphanites. These igneous patches occur in the slates which contain intercalated bands of tuff and slaty diabase near Townstal on the west, and near Norton on the south and south-east.

A small patch of igneous rock is visible in a quarry at Woodbury Farm. Further west, aphanite with cracks lined with asbestus is exposed in a quarry south of Bugford Lane End. Clay is said to have been encountered in the centre of the quarry under the aphanite. Between this rock and Norton no proofs of the occurrence of volcanic bands in the slates were obtainable, but between Bugford Lane End and Cotterbury Green soft tuffs, banded tuffs, and white shales with a steatitic appearance were noticed near Hillfield and Bugford Cross, and a small patch of diabase north of Paddlelake.

There is a small mass of diabase near Pasture Farm, south of Hutcherleigh, quite isolated.

Further south, near the south border of the map, we encounter the chain of diabase patches and volcanic rocks which belong to the Blackpool, Stoke Fleming and Kingswear coast series. These commence with a small patch near Lower Heathfield, a larger one south of Torr, and one near Buckland, apparently in the Dartmouth slates; a craggy mass on either side of the stream in Leader Wood and Burlestone Wood; several small patches, which do not appear to be connected, in and near Leader Wood and near Hansel and North Corn Mill, and at Orestone Cottage. Most of these are hard diabases, and probably intrusive, but it is possible that the last mentioned may be contemporaneous.

The next patch of igneous rock (diabase) is shown to a depth of twenty-five feet in a quarry at Combe Cross. The structure is suggestive of an anticline.

The igneous rocks of the Blackpool Valley consist of aphanites and slaty and sheared diabases. These seem to be in plicated association with grey slates which contain sheared rocks, probably tuffs and lavas, near Middle Blackpool Corn Mill and Venn Cross. The Quarry near Venn Cross is in rather soft sheared green rocks, with steatitic-looking material lining a crack in them. They cannot be traced beyond the quarry, there being no exposures, but they are probably continuous to Middle Blackpool Corn Mill. Hard igneous rock resembling the rocks of the Stoke Fleming coast is exposed in a quarry near Embridge Corn Mill. A band of sheared diabase crosses the valley at Blackpool, and there appear to be bands of sheared felspathic tuff in the Dartmouth slates (as between Kingswear and Brookhill) near Blackpool Bridge.

At the southern extremity of Blackpool Sands, a rhyolitic felsite is exposed in the cliff. It is thus described by Mr. Teall

(No. 3,076): "A compact pinkish felsitic rock showing a marked fluxion structure." Under the microscope, "a few small phenocrysts of plagioclase in an irresolvable felsitic matrix."

The volcanic rock is repeated in Matthew's Point on the south. As it cannot be traced in either case westward, its presence is evidently due to anticlinal folds. In Landcombe Cove there seems to be tuff in the slates.

At the east end of Blackpool Sands buff-weathered igneous rocks, with filmy bands of green hornstone near their junction with the slates on the north, occur in the cliff. These rocks, partly vesicular, alternate with the slates through plication, and are repeated at Leonard Cove, extending to Redlap House. On the east of Redlap Cove a mass of diabase, broken up irregularly by anticlines of red and green slates, forms the coast as far as Combe Point and on either side of Shinglehill Cove.

Between Compass Cove and Blackstone Point there appear to be impersistent volcanic bands in the rock reefs of grey and greenish slates. These rocks, with irregular volcanic intercalations, overlie a mass of slaty diabase in the cliff on the south side of Ladies Cove, the whole being cut off on the west by a fault which runs along the eastern cliff of Compass Cove. They may, therefore, be regarded as the continuation of the Stoke Fleming rocks shifted by fault. Between Venn Cross and Ladies Cove on the south of the high road and north of Little Dartmouth there is a quarry in hard diabase overlain by slates with sheared volcanic rocks. The rocks cannot be traced beyond the exposure. They may, for all one can tell, be the easterly continuation of those in the quarry near Venn Cross. Throughout this area in the grass lands there are no exposures, and those by roads are too meagre to afford any clues by which to trace the volcanic bands.

On crossing the mouth of the Dart we find that the igneous rocks are continued by three masses of diabase on the southernmost part of the Kingswear coast. One of these seems to occupy a syncline in grey slates; it is probably shifted by fault on the east, and continued by the two masses on either side of Old Mill Bay between Froward Cove and Kelly's Cove. North of Kelly's Cove igneous rocks are again encountered in Pudcombe Cove. Here hard sheared igneous rocks form a band about ten feet thick in reddish slates with some hard grit on the north shore, the west side being composed of dark grey igneous rock, resting irregularly on the slates which contain hard sheared igneous rock near its northern extremity. Sheared diabase and buff rocks, which may be tuffs, occur at the western cliffs of Ivy Cove. At ten chains north of Ivy Cove dark grey sheared igneous rocks extend a short distance westward from the coast. Although the continuity of these masses cannot be proved, their general alignment in strike with the igneous rocks of the Stoke Fleming coast scarcely admits of a doubt as to their being the same series, shifted by faults, repeated by folds and occurring in patches severed by denudation.

When the area was surveyed the true relations of the Dartmouth slates were unknown, and no time was specially devoted to a search for fossils. It is therefore uncertain whether higher beds may not be faulted or folded in, but even on this hypothesis the correlation of the volcanic rocks in the Meadfoot beds between Sandquay and Paddlelake with those of the Stoke Fleming and Kingswear coast is scarcely probable, except as belonging to the same general series. In this connection, however, it must be remembered that, although colour distinction is of great value in effecting a broad general separation of the main groups of the Lower Devonian, where unaccompanied by sufficiently marked lithological distinction it is a most unreliable guide to the position of stratigraphical boundaries, so that the occurrence of these igneous rocks in a red slate series or a grey slate series is of itself no proof that the horizons are different.

CHAPTER III.

MIDDLE DEVONIAN.

Under this heading are embraced all the slates, limestones and volcanic rocks between the Lower Devonian on the one hand, and the Upper Devonian shaly *Goniatite* limestones and slates on the other. The lower beds, therefore, represent the Eifelian slates* and limestones, and the uppermost are homotaxeous with, or equivalent to, the *Rhynchonella cuboides* zone, or basement beds of the Upper Devonian of the Continent. The sequence of deposits differs in different parts of the area, and to some extent even in the same district.

In the Torquay and Brixham districts, from the Eifelian slates upward, a continuous accumulation of limestone has taken place; yet in these districts proofs of contemporaneous vulcanicity are locally present, as in the Hope's Nose promontory, in the Babbacombe Cliffs, at Trumland's Quarry in St. Marychurch, and in the faulted limestone forming the south margin of the Mudstone Bay anticline. At Black Head, Torquay, we have proofs of contemporaneous vulcanicity higher in the series, and still better examples are afforded in the area between Torquay and Brixham, near Goodrington. These intercalations of volcanic material in the districts of maximum limestone accumulation are, so to speak, the thin edge of the wedges by which the limestone masses are broken up and replaced, in and on the borders of the areas of maximum vulcanicity.

South and south-east of Totnes the Ashprington volcanic series rests partly on Eifelian slates, partly on Eifelian limestones, and takes the place of the limestone masses, representing the Middle Devonian, and, in all probability, the lower beds of the Upper Devonian.

Volcanic rocks, either emanating from sources in this area of maximum vulcanicity, or from local vents outside it, seem to have partly replaced the Middle Devonian limestones on the east of Yalberton, in Dartington Park, and east of Staverton. About Waddeton, between the Ashprington volcanic development and the Brixham limestone, it appears as if the limestones had been largely replaced by slates, and volcanic rocks.

North and north-east of Totnes, the Berry Park slates† undoubtedly occupy an intermediate position between the Lower

* Under the term Eifelian slates all the slates between the Eifelian limestones and the Warberry grit series of the Lower Devonian are necessarily included, but it does not therefore follow that the lower beds may not represent the uppermost part of the Lower Devonian, for this can only be proved by palæontological evidence.

† A local name given by Champernowne to this type of Eifelian slates, viz., irregular grey slates with brown friable fossiliferous lenticles, occasionally calcareous. He was led to regard them as below the Cockington grits and above the limestones through appearances due to inversion and fault.

Devonian rocks of the Paignton area and the limestones of Dartington, Marldon and Berry Pomeroy, and may therefore be regarded as Eifelian slates. The limestones of this area, however can scarcely be taken as representatives of the limestone developments of Torquay, Brixham and Ipplepen. If we assume that they represent the lower part of these masses, the upper part must either have been denuded or replaced by slates in a synclinal trough which terminates westward in Dartington Park. If denuded, these limestones must be everywhere newer than the slates that bound them, and the Dartington structure would be an anticlinal.

North of Staverton and west of the Ipplepen limestone, the main mass of the limestone is evidently replaced by slates, as there are no developments of limestone between Ipplepen and Yealmpton in the slates and volcanic rocks, which represent the Middle Devonian for a distance of thirteen miles or more along their strike.

It will thus be seen that the Middle Devonian succession differs much in different parts of the area, and is not always uniform in the same locality, although in all cases the Eifelian slates form the basement beds. Hence, whilst the relation of the Middle Devonian, as a whole, to the Lower Devonian clearly brings out the general structure (as shown on the map and sketched in the introductory chapter), the distribution of the limestones, as shown on the map, does not explain the structure of the Middle Devonian areas.

In consequence of variability and constant disturbance, and of the restriction of palæontological evidence to the very few localities that have been carefully worked, any attempt to treat the limestones, volcanic rocks and slates under general headings would be impracticable and misleading. As each district has its own peculiarities, detailed description is necessary, but the rocks will, as far as possible, be treated in ascending sequence. For this purpose it has been found desirable to divide the area into the following districts: 1. The Torquay district; 2. The Brixham district, and district west of Broadsands; 3. The Ashprington volcanic district; 4. The Dartington, Marldon, and Ipplepen district.

General Characters of the Slates.

The Eifelian slates vary from even grey, greenish-grey, and dark grey or blackish, compact or argillaceous sediments, to the irregular slates of the Berry Park type. In places where the Eifelian slates pass up into limestones, as under Daddy Hole Knoll (Torquay) and near Waddeton Boat House (by the Dart), they are red in colour, as also in places in the vicinity of Marldon, etc., where the staining may have been due to filtration through overlying New Red rocks. The slates replacing the limestones are grey or greenish-grey and in places black.

General Characters of the Limestones.

The limestones betray every gradation between a red or dark grey calcareous slate and a pale grey or dove-coloured compact massive limestone.

As a general rule, the calcareous slates and thin-bedded or slaty, dark, somewhat argillaceous, limestones are at the base of the series. Well-bedded limestones are developed in the main masses, and above the shaly basement beds. Massive or thick-bedded crystalline compact coralline limestones characterise the upper part of the masses, but are not confined to it, and may occur at almost any horizon (as at Hope's Nose and at Highlands, near Totnes). The thick-bedded limestones often present a slaty-jointed structure through contortion, as in the cliff bounding Redgate Beach (north of Anstey's Cove, Torquay) on the west. (See fig. 10, p. 63).

Dolomitic limestones occur here and there throughout the district, as at Trumlands Quarry (near St. Marychurch), in Lummaton quarries, at Charles Terrace (Ellacombe), in the Yalberton limestone, in the Ipplepen quarries, near Little Hempston, and in many other places. The massive limestones are often crushed and broken into small irregular pieces. Crinoidal limestones are not confined to any particular horizon, but are, as a rule, most frequent in the lower beds.

Mr. E. Wethered* gives the results of microscopical examinations of specimens of Devonian limestones taken from the Hope's Nose Quarry, the Quarry at Daddy Hole, Lummaton Quarry, and from three localities in the adjacent map Sheet 339, viz., Barton Quarry near Lummaton, Combe End near Kingsteignton, and from the Goniatite limestone (Upper Devonian) of Lower Dunscombe. "So far as the evidence warrants a conclusion being drawn, the Devonian limestones of South Devon appear to have chiefly originated from corals, crinoids, ostracoda, stromatoporoids and fragments of shell, while the Goniatite limestone alone contains foraminifera." "Some of the beds at Hope's Nose and Daddy Hole are almost entirely of coralline origin," and "represent accumulations of coral *débris*."

In most of the slides examined rhombohedral crystals of dolomite were found. "Sometimes they appear in aggregates, at other times as single crystals, and there is no doubt that they are of secondary origin." These crystals "are mostly associated with calcareous organic fragments. This may, perhaps, be explained by the greater solubility of the aragonite as compared with the other form of carbonate of lime of which shells are mostly constructed."

In the table of percentages of residues insoluble in hydrochloric acid, the thin-bedded (Eifelian) limestones of Hope's Nose yielded 13·5 and 18·6, the (Upper Devonian) Goniatite limestones 10·2, whilst the other specimens obtained from different parts of the limestone group between these horizons gave much lower percentages, from 0·2 to 3·5.

* *Quart. Journ. Geol. Soc.* for Aug. 1892. Vol. xlviii. pp. 377-387.

Slides of the thin-bedded limestone at the top of the Hope's Nose Quarry show under the microscope "a light grey finely crystalline ground mass traversed by fissures filled with calcite. In the ground mass are ferruginous patches and minute rhombohedral crystals, apparently of dolomite." Slides of the more massive limestone at the base of the quarry proved "to be composed of broken calcareous fragments, the structure of which has, for the most part, been obliterated." "Higher up in the quarry" the limestone "is largely made up of coral *débris*, polyzoa and stromatoporoids." "Toward the middle of the quarry" is "a series of beds very dark in colour. These sections show an almost structureless ground mass" in which crinoid ossicles, valves of ostracoda, and one or two shell fragments were found, traversed in all directions by calcite suggesting tubules, apparently forms of vegetation. The dark residuum was proved to be carbon with very little doubt.

The Eifelian slates vary in colour and character in different parts of the area, so that their recognition depends to a great extent upon their relations to the overlying limestones. For example, the red, grey and dark slates and shales on the south coast of Hope's Nose promontory, and the reddish grey and dark grey slates and shales which underlie the Daddy Hole limestones, are overlain by Eifelian limestones of a slaty or shaly character. The limestones with rugose corals, which represent the Eifelian limestone in impersistent patches at the base of the Ashprington volcanic series, overlie Eifelian slates; but it does not therefore follow that the basement beds of the various limestone masses are all on the same horizon, even where they rest on, or exhibit a downward passage by intercalation into, slates. Although from Eifelian limestone to slate a passage, more or less gradual but irregular, is shown in such sections as Hope's Nose and Daddy Hole, no such passage is apparent in many places where limestones rest more or less abruptly on slates, as at Upton Farm, Torre Chapel and Torre College, in parts of Ellacombe, in Torquay, and in the Marldon, Berry Pomeroy, and Ipplepen districts. In these cases it is not always easy to decide to what extent slates or shales may have replaced Eifelian limestones, and whether the limestones belong to the Eifelian or a higher stage. This uncertainty makes the correlation of isolated limestone patches, in the absence of distinct lithological and palæontological evidence, very unsatisfactory.

Torquay District.

The structure of the Torquay promontory is a complex anticline, so broken and shifted by faults that the Middle Devonian rocks on its flanks are very seldom found in their normal relative positions. The Lower Devonian may be an offshoot from the Paignton anticline, as before mentioned, or may be isolated by intervening Middle Devonian rocks. The limestone islets of the Shag Rock, the Thatcher, and the Oare

Stone, strongly suggest a barrier of Middle Devonian cutting off the Lower Devonian on the south.

It is, however, quite possible that the Lower Devonian of Torquay and Paignton may be connected between the Shag Rock and the Thatcher in Torbay. Mr. Hunt * remarks: "From the Shag, which is a limestone rock, a reef runs off in a south-easterly direction for some four hundred and fifty yards. This is composed of slate rock or grit, such as we find at Meadfoot, and does not correspond in that respect with the Shag Rock, of which it seems a continuation. From the south point of the 'Thatcher' the bottom is rocky in a westerly direction, and here (about four hundred yards from the 'Thatcher'). . . . my dredge detached a large fragment of slate rock. . . . . About one thousand yards south-east by south of the 'Thatcher' . . . the dredge . . . brought away a piece of grey grit." From these passages it seems likely that there is a connection between the Torquay and Paignton Lower Devonian areas in Torbay. The main structural curves of the Torquay area are obliterated through faults and constant irregular plication; but, notwithstanding this, the spurs of Lower Devonian extending to Babbacombe Church and to Thurlow Road (Torquay) from Warberry Hill prove the complex structure of the anticline, and account for the Eifelian slates and limestones of Ellacombe, as occurring in a syncline between these anticlinal spurs. The general tendency elsewhere has been the production of faults letting down the limestones against Lower Devonian rocks and cutting out the Eifelian slates altogether. The greater effects of faulting and of minor plications in the vicinity of the main structural folds have been pointed out in the introductory reference to the general structure of the area.

The limestones of Torquay and Babbacombe form portions of a plain or plateau which is also conspicuously shown in the limestones of Berry Head and Brixham.† As, with local exceptions, these limestones bridge over the entire interval between the Upper Devonian *Goniatite* beds and the Eifelian slates, it is a legitimate inference that all the slates in the Torquay promontory which are not included in the Upper or Lower Devonian are below the limestone masses, and may therefore be considered Eifelian.

As it has not been found possible to separate Middle Devonian (proper) from Eifelian limestones in the following descriptions, the lower beds of the former must be necessarily included, the remainder being reserved for another section, which embraces what are regarded as the upper beds of the masses.

Lower Part of the Limestone and Eifelian Slates and Limestones.

Localities.—1. Between Daddy Hole and Meadfoot Sands and The Strand, Torquay. 2. Hope's Nose and Redgate Beach.

* "Notes on Torbay," *Trans. Devon. Assoc.* for 1878.

† Pengelly "On the Lithodomus Perforations, etc." *Trans. Devon. Assoc.* for 1866.

3. Babbacombe, Ellacombe and St. Marychurch (open to question).
4. Hele, Upton and Torre.

Daddy Hole.

The Section at Daddy Hole was described by Champernowne in 1874* as follows:—"A mass of limestone between Daddy Hole Plain and Hesketh Crescent is separated from the main mass of limestone, and forms a conspicuous knoll above the west end of Meadfoot Beach, but it does not appear to have been generally recognised as a repetition of beds. If we descend to the little cove which we may call 'Daddy Hole' or 'Syracusa' Cove, leaving the base of the limestone of Daddy Hole Plain, we pass over a band of shales, which to all appearance are interstratified between that limestone and the beds constituting the knoll before referred to. The foot of the path, close to the beach, is over huge blocks of limestone fallen from the cliffs above, but immediately on the right we have a mass of the grey or olive-coloured shales (or slates) in which, although a cleavage is developed, the bedding is on the whole quite distinct. They contain a few crinoidal remains and Brachiopoda, not easy to get out complete, and the universal *Atrypa reticularis*, Linn., was all I could recognise. Beyond here, for some way, they are weather-stained red till near the limestone. Thin-bedded calcareous layers, brownish and reddish, pass gradually into the limestone above, and contain first a great number of Polyzoa, which, though fragmentary, are often beautifully preserved, with one or two peculiar forms of crinoidal joints, etc., and then immediately above, if not in the same layer, *Calceola sandalina*, Linn., in a thin-bedded red shaly limestone, in considerable numbers, together with simple corals (*Cystiphyllum* and others). . . . . The passage beds . . . . dip below the limestone at an angle of 35°. . . . . Recrossing to the east end of the little beach, we observe that it ends abruptly against a great face of limestone, which plunges under the sea at a mean angle of 40°. On approaching this limestone the slates are similarly reddened, and the passage layers of limestone can be seen in section immediately above the face just mentioned. There is no material difference between the appearance of the passage on the one side and that on the other. *Calceolæ* occur on this side as well, and are not uncommon in the red shaly limestone which forms the slope of the hill, where, it is worthy of remark, they were lying for the most part flat side up, which, if the beds be inverted, is what we might expect. I have looked for them, but so far without success, under the quarry on the north-east or Meadfoot side of the knoll,† underneath which are again shales, weather-stained red, which strongly resemble those we had before in the cove. Their fossiliferous character in Meadfoot Bay was long ago pointed out by Professor Phillips."‡

* "On a Contortion of the Limestone of Torquay and the Presence of Calceola Sandalina at its Base." *Trans. Devon. Assoc.* for 1874.

† I have obtained several specimens of *Calceola* in the red limestone shales on the Meadfoot side of the knoll.

‡ *Pal. Foss, Cornwall, Devon, etc.*, page 204.

"If, then, we are right in regarding this hill of limestone as the Rock End and Daddy Hole beds repeated by some means, we should expect to find that they possess many characters in common. Accordingly, we find that such is the case. Both lithologically and palæontologically they are, in fact, identical. The *Murchisoniæ, Favosites, Syringopora,* etc., besides many more of the common corals, occur in both. The two last mentioned are found associated near the Rock End wall and 'London Bridge,' on the west side of the cove, and on the east side at the point of limestone directly opposite the Shag Rock, known as Triangle Point. The *Murchisoniæ* I have found close to Rock End Wall, and Mr. Lee tells me he has found them in the old quarry on the east side of the cove." . . . . "The wrench which has formed the subject of this communication appears to be traceable from the coast by a boss of limestone overhanging Hesketh Mews, and another isolated piece near 'The College.' These may, however, owe their position to this twist, combined with a fault crossing from near the Post Office to Hesketh Crescent." The little promontory of limestone (Triangle Point) at the south end of Meadfoot beach is cut off from the limestone of Daddy Hole Knoll by a nearly east and west fault, which is filled with broken limestone and calc spar. This fault has a downthrow to the south, decreasing westward and passing out into two or three small dislocations visible in the cliffs on the west side of Daddy Hole. Traces of gold were met with in the calc spar of the fault rock, on the south side of the quarry, on the east of Daddy Hole, but the gold fever this discovery produced was speedily allayed by a small dose of unremunerative prospecting.

The succession under Daddyhole Plain is as follows in descending sequence:

1. Thick-bedded grey limestone.
2. Irregular thin-bedded grey limestone, partly slaty and shaly, and containing buff earthy matter, about 15 feet thick.
3. Dark grey slates, weathering greenish, with lenticles of limestone and fragments of corals and crinoids.
4. Dark grey slates, weathering greenish, with calc-spar veins, very fossiliferous in places, notably at about 30 feet below the limestone. In one part of Daddy Hole Cove (Daddy Hole) the slates are stained red for about 40 feet vertically downward from the limestone; the colour change has a breadth of about 20 yards. Herr Frech obtained *Monticulipora* allied to *M. fibrosa, Calceola sandalina, Pentamerus galeatus* and *Cyrtia Whidbornei*, Davidson, in Daddy Hole Cove, in 1888.

The Rev. G. F. Whidborne * notes the discovery of numerous specimens of a new genus of Ostracod, named by Prof. Rupert Jones *Kyamodes Whidbornei*, in a quarry on Daddy Hole Knoll. *Athyris concentrica* and a doubtful *Vermetus* were found in the same bed which forms one of several thin bands, alternating with shale and underlying thick-bedded grey limestones.

On the east side of Daddy Holl Knoll the descending sequence is as follows:—

1. Thick-bedded bluish grey limestone.
2. Rather thin and irregularly-bedded dark grey limestones.

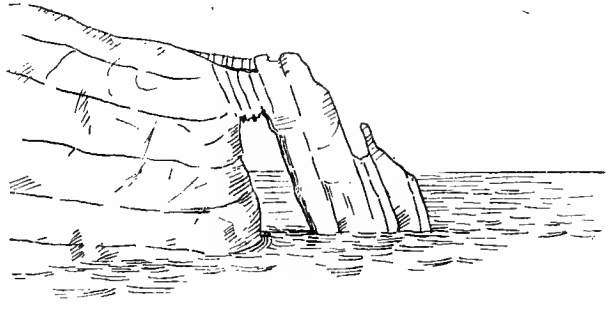
* *Ann. and Mag. of Nat. Hist.* for October, 1888, p. 299.

3. Red shaly limestone and partially calcareous shales in which several examples of *Calceola sandalina* were obtained, besides *Phacops*, *Atrypa*, *Leptæna*, *Orthis*, *Spirifera* and *Fenestella*.
4. Dark grey shales with occasional beds of limestone and small limestone lenticles, enclosing fossils such as *Spirifera* resembling *Sp. speciosa* and *Fenestella*.
5. Dark grey and greenish shales and slaty beds with calcareous patches.

Lower in the series the slates are very dark grey or blackish, and contain harder bands and lenticles of mudstone, as well as signs of interbanding with films of a coarser texture and paler colour. In places the reefs are of a vivid pale-green colour suggestive of the presence of copper ore, and a purple colour is noticeable in them by the steps leading up the low cliff from the beach to Meadfoot Road.

The Eifelian slates are evidently cut off against Lower Devonian rocks at the east end of Hesketh Crescent. The patch of limestone at Hesketh Mews* is on the south side of this fault—and on the north side of it is the college (Apsley House) limestone. Between the Hesketh Mews and Apsley

FIG. 4.—LONDON BRIDGE, TORQUAY.



House limestone patches a shaft was sunk during the construction of the Torquay sewer, near the junction of Middle Woodfield Road with Meadfoot Road. In it calcareous beds were encountered at a depth of 104 feet under the dark slates. Whether this phenomenon is due to the faulted junction of the Middle and Lower Devonian having so oblique a southerly hade as to allow of the superposition of Eifelian slates on Meadfoot beds at this spot, or to the occurrence of calcareous beds low down in the Eifelian slates, there is now no means of ascertaining.

The coast between Daddy Hole Cove and the Bath Saloons shows the contorted character of the Daddy Hole limestones. At Magwintons (Fig.5) the limestones exhibit an inverted syncline (with steep seaward dips from which the beds rise gently landward). The natural arch of London Bridge (Fig. 4), further west, is on the prolongation of this synclinal, the rocks forming the bridge being thin beds immediately on the seaward side of the axis from which the beds rise gently landward. The floor of Dyer's (or "the Old Land's End") Quarry "with its dense reef-like growth

* Compare limestone of Charles Terrace, Ellacombe.

of *Cyathophyllum cæspitosum*, and other corals * " is on the continuation of this axis. At Land's End *Cystiphyllum vesiculosum* has been found in the limestone. The cliff hard by bounding Petit Tor Cove † seems to be on the face of a fault, which, prolonged northward, probably shifts the limestone boundary near Engadina Villa, and in its further prolongation throws the Apsley House limestone on the east against Lower Devonian on the west. The cliff face at Petit (Peaked) Tor Cove shows a normal anticline in the limestones. The Bath Saloon is built upon rather massive-bedded grey limestone, but the cliffs eastward often consist of reddish shaly or slaty limestones, which might belong to the Eifelian. The Apsley House limestone is a triangular patch apparently bounded on all sides by fault. At the Presbyterian Church reddish, slaty limestones are exposed; they may belong to the Eifelian.

In the valley between Victoria Parade and Asheldon Copse the evidence is altogether insufficient to enable one to trace the relations of the rocks with approximate certainty.

FIG. 5.—CONTINUATION OF THE LONDON BRIDGE SYNCLINE AT MAGWINTONS, ¼ MILE TO THE EAST.

Behind the Torquay Natural History Society's Museum, and in the foundations, greenish-weathered fossiliferous ‡ slates were excavated. Near this, at the Winter Garden, reddish shaly limestone and shales were observed. These beds overlie the limestone of Braddons Hill, and are, no doubt, inverted Eifelian slates and limestones.

Pengelly informed the writer that the foundations of Lisburn Crescent disclosed limestone associated with slate. Behind the Crescent there is a cliff of compact crystalline pinkish and grey limestone shattered by irregular joints. This compact limestone is suggestive of beds higher in the series, although the limestones and the slates in the foundations may be Eifelian. The prolongation of the fault which throws the Braddons Hill limestone against Lower Devonian rocks in Market Street seems to cut off the limestones of Lisburn Crescent on the south side of Erinville.

A small mass of crushed and broken (dolomitic ?) limestone is exposed in a small quarry by Lower Warberry Road, just within

* Champernowne, *op. cit.*

† Or Peaked Tor, not to be confounded with Petit Tor near St. Marychurch, at the north margin of the map.

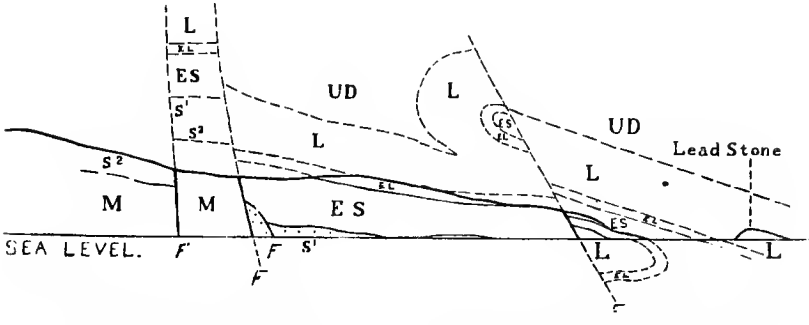
‡ The Rev. G. F. Whidborne has examined the fossils obtained in the excavations, and collected by the late Mr. Else. See *Geol. Mag.* for Dec. 1901.

the grounds of Wellswood House. This limestone probably occurs at the coalescence of faults, which, in the absence of evidence, cannot be traced. It may rest on Eifelian slates, as grey slates are evidenced at Wellswood Park, but their relation to the Lower Devonian grits and slates on the north is not visible.

Hope's Nose.

A fault roughly coincident with a line drawn from the west end of Hope's Nose Quarry across the promontory in a south-westerly direction cuts off the Lower Devonian rocks against Eifelian slates.* These rest on the top beds of the Lower Devonian, and are partly capped by slaty limestone (*i.e.*, the base of the Eifelian limestone). Therefore (unless partly cut out by thrust faults), we have here the whole thickness of the Eifelian slates—about 180 feet.

FIG. 6.—DIAGRAM SHOWING THE RELATIONS OF THE DEVONIAN ROCKS AT HOPE'S NOSE.



U D = Upper Devonian.
L = Middle Devonian limestone.
E L = Eifelian limestone.
E S = Eifelian slate.
S¹ S² = Upper and lower part of Staddon grits.
M = Meadfoot beds.
F F = Faults.

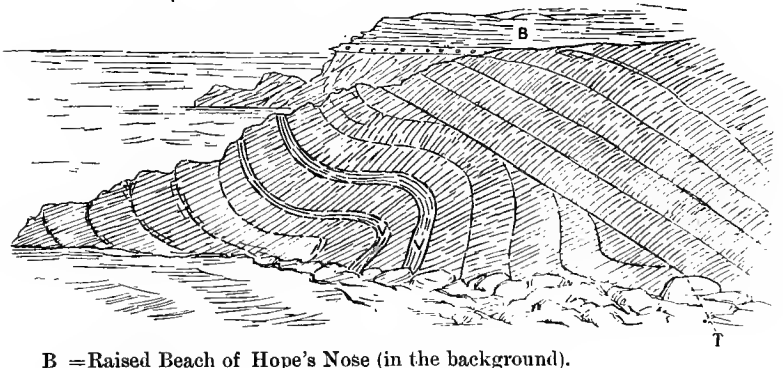
For some distance below the capping of buff-weathered slaty limestone, the shales are partially calcareous, very fossiliferous, and contain slaty limestone. They weather pale grey and buff-brown, but, toward the fault, are peroxidated for a considerable vertical thickness. These beds are underlain by blackish slates or shales,* with bands and lenticles of dark grey brown-weathered mudstone, and, occasionally, of dark limestone; they rest directly on the Lower Devonian grit. The relation of this section to the limestone of either horn of the Hope's Nose promontory is obscured by a fault, which is well shown near the Raised Beach, and has a distinct hade eastward. This fault meets the N.E. and S.W. fault, at the west end of Hope's Nose Quarry. The beds let down by it are thick-bedded grey limestones, overlain by thin-bedded and slaty limestones, which form the low cliff and foreshore reefs for most of the way between Hope's Nose

* Strictly speaking, the Eifelian slates are either slates or shales, or slaty shales according to the accidents of plication.

and the Raised Beach. These slaty and thin-bedded limestones are unquestionably Eifelian, and they are overlain by slates which occupy a shallow syncline. The succession here is, therefore, a reversal of that of Daddy Hole. It can only be explained by inverted structures, as shown in the accompanying diagram (Fig. 6).

We have thus, in the Hope's Nose promontory, a normal and an inverted succession, the inverted succession supplementing the normal one. Hope's Nose is composed of massive or thick-bedded pale grey limestone, often compact and pinkish * (described by Kayser as a coral reef) containing *Stromatopora*, *Heliolites porosus*, simple *Cyathophylla*, *Cystiphyllum vesiculosum*, etc. In the quarry this limestone is exposed to a depth of about thirty feet, and is overlain irregularly by from twelve to twenty feet of thin dark grey limestone beds. On rounding Hope's Nose and proceeding southward, the reef composed of massive limestone is bounded by a low cliff of the thin-bedded limestones, which become slaty towards the Raised Beach. The thin lime-

FIG. 7.—SKETCH ON THE COAST AT HOPE'S NOSE.



B =Raised Beach of Hope's Nose (in the background).
T =Thrust fault.
V V=Volcanic tuff.

stones rest, as in the quarry, on an irregular hummocky floor of the massive rock, presenting appearances of truncation, etc., which Kayser attributed to deposition on and against the irregular surfaces of the reef. If this explanation is the only one, the beds cannot be inverted. It must, however, be remembered that in such an explanation as has been given the friction and pressure, at the junction of the massive and thin-bedded rocks would be likely to produce irregularities as well as sharp plication accompanied by thrusts, such as are exemplified further on.

The massive limestone platform dips under the sea-level a short distance to the south of the outfall of the Torquay sewer. From this to the Raised Beach the cliff and beach reefs are in slaty limestones, slates above them occurring in one place at the top of the cliff. The Raised Beach is on a platform of massive

* Compare the coralline limestone of Highlands Bridgetown, Totnes, which seems to be Eifelian, and the limestone behind Lisburn Crescent.

bedded limestone, which has emerged from beneath the slaty and thin-bedded limestones. On the summit near the Raised Beach the thin-bedded limestones are contorted and thrust over, or obliquely faulted against the massive rock.

In the slaty limestones a thrust is also visible at about 150 yards from the Raised Beach, but it is impossible to say whether it is a continuation of that above mentioned. Below this thrust (*see* Fig. 7) the slaty limestones are contorted, and contain two intercalated bands of volcanic tuff two feet apart. These bands, respectively eight and six inches thick, are visible for sixty or seventy yards.

The dark slaty limestones are intersected by calc-spar veins in places, and they appear to pass into slate. In the low cliff where the limestones are shaly they are often partly decalcified to buff indurated earthy material,* and contain numerous fossils. *Phacops latifrons* is said to be abundant in the shales above the limestone.† In the following list the fossils obtained by Dr. Kayser are supplemented by those identified by the Geological Survey palæontologists and by Mr. Whidborne, which are respectively distinguished by appended letters S. and W.

Cyathophyllum heterophyllum
Heliolites porosus.
Fenestella arthritica. W.
Hemitrypa oculata. W*
Rhabdomeson ? similis. W.
Athyris concentrica ? W.
— rugata. W*.
Atrypa aspera. S.
— desquamata. S.
— reticularis.
Bifida lepida. W.*
Kayseria lens.
Leptæna interstrialis.
Orthis arcuata. W.
Pentamerus galeatus.
Productus pustulosus ? W.
— subaculeatus. S.
Rhynchonella parallelopipeda. W
— procuboides.
Spirifera curvata (typical shape).
— speciosa.
Streptorhynchus umbraculum.
Platystoma sigmoidale. W*.
Scoliostoma (Turbo) texatus. S.

The four fossils in the list with W* are referred to in Whidborne's Monograph, vol. i., p. 199 ; vol. ii., pp. 100, 102, 180.

Calceola sandalina has not been found in the Hope's Nose slates and limestones.

Redgate Beach.—The next place on the coast where the Eifelian isrepresented is Redgate Beach, a sketch of which is figured (Fig. 2). Here the Eifelian limestones are very dark grey, irregularly shaly and thin bedded, and apparently in plicated association with pale grey coralline, apparently massive, but really somewhat shaly, limestone. The dark beds have the appearance of folding round the pale grey limestone in much the same way that the Hope's Nose thin limestones are assumed to be folded round the massive beds, and they are brought up by a fault which runs coincidently with the massive limestone cliff behind them. In specimens obtained from the dark limestones Mr. Whidborne has identified

* The Eifelian limestone near Springville House, north of Totnes, is of the same type.

† Whidborne, "Monograph of the Devonian Fauna, etc." ; "Limestones of Lummaton, etc.," Part i., p. 7, 1889, Pal. Soc.

Alveolites suborbicularis, a small *Pachypora* (*cervicornis*?), a *Cyathophyllum*, similar to *C. Roemeri*, and *Atrypa reticularis*.

Between two faults in the massive limestone cliff thin-bedded shaly reddish limestone, apparently resting on shales, are brought up. These also are probably Eifelian. The extensive under-cliff of slips, talus and limestone blocks, which bounds Redgate Beach, effectually conceals the faulted relations of the Eifelian slates and limestones; slates of the same dark character as the lower beds in the Hope's Nose and Daddy Hole sections are, however, exposed on the margin of the broken ground bordering the beach, and as grits associated with chocolate-coloured shales denote the occurrence of Lower Devonian, it is probable that, although cut up by faults, we might find the whole Eifelian slate series represented, if the slipped material and talus were removed. No systematic search for fossils was made in this locality.

Babbacombe.—The limestones of Babbacombe Cliff are evenly bedded in thin layers with occasional thicker beds. In the road to Oddicombe Beach they pass downward into slates with calc spar veins and, here and there, irregular beds of limestone. *Atrypa reticularis* was recognised amongst the badly preserved fossils in one of these beds. The further observation of the slates is prevented by slips and talus obscuring the surface between the cliff and the beach below. The slates are cut off against New Red rocks, on the north, by an east and west fault, which is exposed on the coast. From the fault to beyond the Half Tide Rock, where the limestones overlie them on the beach, dark slates or slaty shales are visible. Near the junction they are intersected by calc spar veins and contain hard bands, probably calcareous.

At the Half Tide Rock an irregularly intrusive igneous mass occurs in these slates, and a large mass, with less clear relations, is exposed near the fault. These are evidently the rocks described by Dr. Busz * as a Labrador porphyry rock (allied to the leucophyres, as the ground mass consists almost entirely of felspar) and a compact diabase.

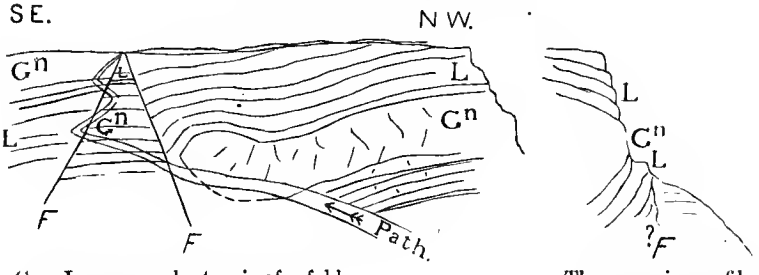
The Carey Arms is on purplish slates, apparently on decomposed red and brown weathered igneous rock (a granular diabase). This slate continues to the Glen, and it is possible that it may be either a stained continuation of the dark slates or even Upper Devonian cut off by fault.

In the Babbacombe Cliff the limestone is affected by zigzag plications, the axes of which run, more or less, coincidently with the cliff face; this, in consequence, gives at first sight the appearance of nearly horizontal bedding with an interbedded impersistent mass of igneous rock, mostly decomposed. Closer inspection, however, shows that the igneous mass is along the axis of a curve through which it has been exposed, by the denudation of the limestones which originally wrapped round it, (Fig 8).

* *Sitz. d. Niederrheinische Gesell. im Bonn.*, 1893, p. 85.

This mass is either an intrusive sill, perhaps connected with the rocks below, or a contemporaneous volcanic rock. It is shifted by a couple of faults crossing a path up the cliff and in line with its southernmost exposure. About sixty yards from this the zigzag contortions are very well shown (Fig. 9). With such a structure it is evident that the superposition of limestone on slate is quite inconclusive as to their relative position. In this

FIG. 8.—UPPER PART OF BABBACOMBE CLIFF NEAR THE ROYAL HOTEL.

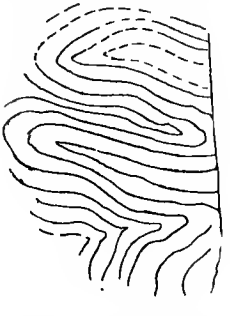


Gn=Igneous rock at axis of a fold.
L =Limestone, even-bedded.
FF=Faults.

The same in profile on the north-west side of the faults.

case, however, the dark slates correspond in character to those in Dartington Park and in the Broadhempston area as well as to the lower part of the slates in the Daddy Hole and Hope's Nose sections. They cannot be Upper Devonian, so that the only alternative is one suggested for these dark slates from a cursory inspection by Dr. Kayser,* viz., that they may belong to the *Stringocephalus* horizon and correspond to the Wissenbach and

FIG. 9.—CONTORTIONS IN BABBACOMBE CLIFF.



Goslar slates. This would not apply to the Hope's Nose and Daddy Hole sections, and its application to this section would imply the local breaking up of the Torquay limestone mass by a series of intervening slates.

In a district so faulted and contorted the local separation of the lower from higher beds of limestone by the deposition of mud, in an interval attended by slight volcanic disturbance,

* *Op. cit.* p. 187.

would be very hard to prove. Such a theory might account for the difference in the character of the Ellacombe limestone and for the relations of the St. Marychurch limestones, and those of Torquay Cemetery, etc. This explanation, as will be seen further on, applies to phenomena in the Goodrington, Yalberton, Dartington, Broadhempston and Whilborough districts, otherwise difficult to explain.

The Babbacombe limestones are faulted against the Eifelian slates and Lower Devonian rocks on the west. Near Bishopstowe this boundary is shifted by a cross fault, on the north of which shaly irregular limestones, perhaps Eifelian, are exposed by the Babbacombe Road. There is no evidence of the nature of the rock between Asheldon Copse and Bishopstowe. At the east end of Babbacombe, opposite Bennetts' cottages, irregular dark grey red-weathered shaly limestones, with occasional intercalations of shale, are exposed in a small quarry.

Ellacombe.—The Eifelian slates of Ellacombe weather grey and greenish; their junction with the Lower Devonian of Warberry Hill, where not faulted or over thrust, seems to be inverted, as, for instance, south of Warberry Mount, and perhaps at, or near, the Western Hospital. In the new road, north of the Western Hospital, greenish and red slates or shales are exposed, but no characteristic fossils were obtained in them.

The position of many of the limestone patches can only be accounted for by fault, and it is possible that some of them owe their position to thrusts.

In Ashill Road a large patch of rather thick-bedded grey limestone is faulted against the Lower Devonian; it is exposed in a quarry face on its eastern border, and also at its southern extremity. There is no exposure between this and the neighbouring masses of Charles Terrace and the Maisonette, which are well defined by feature.

The Charles Terrace limestone is exposed in a quarry near its eastern extremity, where the rock has a saccharoid dolomitic aspect, and has been crushed into small pieces. In the centre of the quarry a dyke-like pulverised rock is conspicuous; it is probably due to the decomposition of the more crushed portion of the limestone. Bedding seems to be irregular and more or less horizontal, if the indications taken for it are not crush planes.

The Maisonette limestone is well exposed in quarries. The rock is pale grey and crystalline, and is broken by irregular joints; it appears to be faulted against the slates on the south. There are two small patches of limestone, bounded by fault on the east, in the market gardens at the foot of Warberry Hill. A small patch of grey massive, or thick-bedded, limestone is exposed at the bend in the Lower Bronshill Road, south of Homelands.

All the above may be placed in the same category, viz., limestones which show no appearance of passage into the underlying slates, and which, therefore, suggest basal thrusts or faulted boundaries.

Between these limestones is a larger mass. This is irregularly associated with schalsteins at its eastern extremity, both being probably cut off by fault. The south-eastern part of this mass consists of limestones with nearly vertical bedding, and is separated by a band of tuff from the main mass.

In a quarry near the Ellacombe National School the limestone is irregularly associated with grey slates. By lower Bronshill Road and by the lane to Hill Park (north of the St. Marychurch Road) dark grey limestone beds, associated with slates, were observed. The association with slates renders the boundaries of this limestone mass very indefinite, whilst it strongly suggests the normal Eifelian limestone type. On the north of the Charles Terrace limestone a trace of volcanic rock was noticed in the slates.

Upton Farm Limestone.—A mass of limestone, overlying the slates on the west, is well exposed in a quarry by the road in Upton Vale, on the north of Upton Farm. The rock is partly crinoidal and in tolerably thick beds, partly thin-bedded and shaly. East of Upton Farm, near Matchwood Terrace, lenticular limestone beds were seen in the slates.

The slates near Hill Park and Upton Cottage are dull greenish-grey, and contain vesicular igneous rock, probably intrusive. Near their junction with the Upton Farm limestone, on the south, and the Daisons limestone, on the north, the slates are red stained. The junctions may in both cases be faults. It is probable that the boundary with the Daisons limestone is a continuation of the fault on the south of Oddicombe Beach.

Daisons Limestone.—Near Daisons Farm, on the south side of the fault, pale grey limestone, apparently dolomitic, is exposed in a small quarry opened for gravel, as the rock is broken into small pieces by the crushing it has undergone.* Eifelian limestones probably make a natural junction with the slates from Daisons Farm eastward, but no indication of the nature of the rock could be obtained. The Daisons limestone is much plicated and faulted. The Daisons Rock crags indicate inverted plications with a northerly dip, and faults and crushed rock are shown in the large quarries by the Teignmouth Road. These disturbances probably counteract the fault in the direction of Oddicombe Beach, which has a downthrow to the north, and bring in Eifelian beds north of the Daisons House and Westhill Farm. Thin limestones, overlying slates with traces of tuff, and dipping north, are exposed near Westhill Farm, behind a house by the road to St. Marychurch (West Hill), and by the road to Hele (Black's Hill). The thin limestones and slates may be sandwiched between two nearly parallel faults between Hele and Windmill Hill, or they may be brought up by an anticline.

St. Marychurch Limestone.—From Cary Farm to Trumlands Quarry there are very occasional indications of the presence

* Compare the Charles Terrace limestone and the limestone patch near Wellswood House.

of tuffs and slate, on the slope below the broken, rubbly, grey limestone on which Cary Castle stands; its boundary with the New Red is exceedingly vague. In Trumlands Quarry, buff, grey-brown, and red, much decomposed, hard and soft calcareous tuffs rest on (partly dolomitic) limestone, which is thick-bedded in places, though for the most part in thin beds, and in parts irregularly shaly or slaty. The dip is northerly, at an angle of about 35°. In the corner of the quarry there appears to be a fault, and in another place irregular displacements or thrusts. *Heliolites porosus* and *Stromatopora Hüpschii* (in the *Caunopora* state) were obtained in this quarry, and identified by the late Prof. Nicholson. The tuffs are again encountered in Mount Pleasant quarry (in the north part of St. Marychurch). Here they are of a purplish colour, and contain hard, irregular masses of (apparently) dolomitic breccia. They dip northward at an angle of 55° under pale grey limestone beds, which are much shattered. From these quarries the tuffs would seem to be in a syncline, and therefore above the limestone. It should be mentioned that the Petit Tor faults, prolonged westward, may have something to do with this peculiar rock, and it is just possible that it may mark a line of excessive crush, along which dolomitization had subsequently taken place. The limestones of Mount Pleasant Quarry dip under red shales or slates. The boundary can be traced across the high road south of the Palk Arms Brewery to the lane between Barton Road and the Lummaton Quarries, where it is lost in the low ground. In an orchard west of the Palk Arms Brewery rather even-bedded limestones were observed dipping under hard shaly mudstones and shales, at an angle of 20°. Similar tuffs to those in Trumlands Quarry are associated with the shales. It appears, therefere, that these limestones are lower than those in the Lummaton mass adjacent, and if evidences of the superposition of shales and schalsteins upon them may be relied on, that there was here an interval during which local vulcanicity and muddy sedimentation took place. From the nature of the evidence it is impossible to connect this episode with other cases in the Torquay promontory to which a similar explanation may apply.

Hele, Upton, and Torre district.—Between Hele Cross, Hele, and Windmill Hill, dark grey irregularly-bedded limestones, of the Ellacombe Eifielian type, are exposed.

In the higher part of the Torquay Cemetery slaty and irregular broken limestone beds have been proved, in places, to a depth of twelve feet. In the path by the greenhouse, near the southern Mortuary Chapel, broken blue limestones (red stained on the surface) rest on red and lilac shales, with clay seams and lenticles of fossiliferous limestone containing *Atrypa reticularis* and *Spirifera speciosa*.* In the exposure, which was fourteen yards in length and about two feet in depth, the slates seemed to form an anticline. On the east side of the Cemetery grey slates and yellowish clay, with occasional beds of limestone, occur on the

* Identified by Messrs. Gosselet and Barrois.

higher ground, and dark slates on the lower. These are bounded by New Red clays on the west, and shifted by fault on the south. Beyond this the slates, with one small and one large mass of limestone (on the north side of the Cricket Ground), much crushed and broken, are surrounded by the New Red rocks, as are also two limestone inliers, at the Pavilion entrance to the Cricket Ground and near the Teignmouth Road. The New Red rocks are faulted on the south against the reddish and greenish (presumably Eifelian)* slates which separate the limestone masses of Stantaway's Hill, Torre College Hill, and Chapel Hill. The western boundary of the middle limestone mass (Torre College) is a fault. In the apex of the acute angle made by this fault with the faulted boundary of the New Red, on the west of the Cricket Ground, a knoll of crinoidal limestone, interpenetrated by vesicular diabase, is conspicuous.

The Torre College limestone, where exposed by the road to the Cemetery, is distinctly bedded; it overlies greenish slates on the east; these contain volcanic materials at the junction near Palestine Villa, and there are also traces of similar origin in the slates beyond the reservoir. Between the western fault boundary of this limestone and the grey limestone of Chapel Hill the slates are reddish.

The Stantaway's Hill limestone is well exposed in a long quarry behind Prospect Place. The quarry faces are in part faults, or crush planes, against which the lowest beds, consisting of thin-bedded broken limestones, dip westward. Reddish shales or slates, apparently dipping under the limestones, were exposed by the Teignmouth Road. Stantaway's Rock is a whitish massive limestone which dips east. It appears to be cut off by fault against the Windmill Hill limestones, which are exposed in a quarry exhibiting, in the lower part, shaly limestones intercalated with partly calcareous shales, dipping N. 35° W. at an angle of 35°, and perhaps representing the Eifelian limestones. On the east of Stantaway's Rock, by the Teignmouth Road, massive grey limestones are irregularly overlaid by reddish shaly limestones with an appearance of discordance. In this case the shaly limestones may be Eifelian thrust over the massive rock. In the absence of clear junction sections, and in the presence of faults and thrusts, there is nothing to contradict the supposition that the three limestone masses of Chapel Hill, Torre College Hill, and Stantaway's Hill contain in their lower beds representatives of the Eifelian limestones, and are parts of an originally continuous mass repeated by faults and folds. It is these horizons that seem to be represented by the Marldon and Berry Pomeroy limestones, and the Whilborough and Bulleigh Barton limestones may be embraced in the same category, viz., uppermost beds of the Eifelian, and lowest beds of the Middle Devonian.

* If not Eifelian, these slates would have to be considered as intercalated in the Middle Devonian and corresponding to those above the St. Marychurch limestones, roughly speaking.

Mudges Copse Limestone.—The limestone of Mudges Copse is probably the southerly continuation of the Stantaway's Hill mass; it is faulted against Lower Devonian on the east, and seems to overlie the Eifelian slates on the south of Upton Farm. A section, now concealed, behind a new house in the Lymington Road, showed reddish-stained shaly limestones associated with shales overlying red partly calcareous shales with lenticular limestone, cut off by a fault, or thrust, with a northerly hade at a low angle, against greenish slaty shales with limestone lenticles. Further south the limestone forms a grey broken rock, evidently higher in the series.

Tor Hill Road Limestone.—A cliff of limestone rises above the Torre Parish Church (St. Saviour's). By the Tor Hill Road it forms a conspicuous crest of white limestone, much fractured, and similar to Stantaway's Rock. The absence of exposures in Brunswick Square renders the northern boundary of the mass very uncertain. It appears to be a continuation of the Torre College limestone shifted eastward by fault. The alluvium of the Upton Valley probably conceals its faulted junction with the Lower Devonian. On the south, at Upton Parish Church, there are some slight indications of the association of slates with limestone beds. If not faulted on the south against greenish Eifelian slates, the latter form an inverted anticlinal; slates separating this mass from that of Waldon Hill. The most northerly exposure of the Waldon Hill mass, near the Coffee Tavern (in a narrow bye-street parallel with Union Street), is a cliff of thin even-bedded limestones and shaly limestones and shales, which dip northward at an angle of 36°.

From the foregoing notes it will be seen that no boundary between the Eifelian limestone and the *Stringocephalus* limestone (or Middle Devonian proper) has been defined. Although the lower beds of the limestones, where they exhibit a passage into underlying slates, have been certainly claimed as Eifelian, every attempt to limit their upward extension must be based on minute palæontological research. Where massive or thick-bedded limestones rest directly on the slates, the possibility of their being Middle Devonian limestones pushed out of position by thrust planes, or of the local replacement of thin-bedded or slaty Eifelian limestones by slates, is suggested.

Torquay District.

Upper part of the Limestones.

Hitherto the Middle Devonian limestones have been described in their relation to the Eifelian; in this section, they have to be considered in relation to the uppermost beds of the masses, which should be taken as homotaxeous with the *Rhynchonella cuboides* zone, constituting, on the Continent, the basement beds of the Upper Devonian.

Champernowne, in unpublished notes, alluded to the occurrence of "occasional *Stringocephali*" in the limestones of

Lummaton and Woolborough, where *Rhynchonella cuboides* is most abundant. As these limestones belong to the upper part of the masses of Torquay and Newton Abbot, he remarked that *Rhynchonella cuboides* "either lived earlier in Britain than the Continent, or the *Stringocephali* survived later."

Unfortunately, in Lummaton Quarry, the spots where these fossils are found are very restricted, and a similar shelly mass has not been elsewhere encountered in the Torquay limestones. It is therefore impossible to draw any palæontological boundary in them. If, however, the upper parts of the mass exhibited a uniformly massive character, and were succeeded regularly by distinctly bedded limestones, a line could be drawn to denote these characters, although it would have only a relative palæontological value. This, however, cannot be done, in view of the disturbed character of the rocks, and, if practicable, might not represent a definite stratigraphical horizon. It is necessary to include the upper beds of the limestone masses in the Middle Devonian on stratigraphical, as well as palæontological grounds, at the same time leaving the question of the representation of the *Rh. cuboides* zone perfectly open.

The only section which gives anything approaching to a clue to the thickness of the Middle Devonian limestones is the record of the Torquay Brewery Well, at No. 34, Fleet Street, given by Mr. H. B. Woodward,* and in White's Directory. The site of this well is in the valley between the limestones of the Braddons and Waldon Hills. As the uppermost beds are probably unrepresented, and part of the lower beds may be cut out at a faulted junction with the Eifelian slates, the total thickness of the Torquay limestones cannot be inferred from the section. The inclinations of the limestone and underlying slate at 70° (if not cleavage) and 45°, respectively, give the true thicknesses, approximately, as follows:—

	Feet
Varieties of Petit Tor Marble (in beds from 3 to 6 feet thick)	35
Dark liver coloured shillety limestone with quartz veins Blue, pink, and chocolate, plain limestone -	85
Limestone	120
Soft tenacious red clay probably denoting a fault :	
Blue slate	58
Chocolate slate	46
Blue slate	68
Slate	172
Indurated red marl (probably Lower Devonian).	

From this it would appear that the section in the upper part consists of rock of the same character as that of Wallshill, north of Redgate Beach, upon slaty limestone similar to that in the

* *Geol. Mag.* for Oct. 1877, and White's 'History of Torquay.'—See also Well Sections, pp. 126, 127. There is a slight difference between Woodward's and White's sections in thicknesses. The latter is more detailed in description of the limestone.

cliff bounding Redgate Beach on the west, and to reddish slaty limestones in the Rock Walk Cliff, by the road to Torquay Station. Just as it is legitimate to infer that the limestones in connection with the Eifelian, embraced in the previous section, are the lower or middle parts of the limestone series, so it is reasonable to regard all limestones in unfaulted or slightly faulted contact with the Upper Devonian Goniatite-beds as the uppermost parts. The limestones of Ilsham and Devil's Point* and the Petit Tor limestones belong to this class, on direct evidence, and with them, on less direct evidence, are included the limestone of Wallshill (between Long Quarry Point and the Carey Arms). of Lummaton, of part of Waldon Hill.

It is probable that the higher limestone horizons are also present in parts of the Windmill Hill, Daison, and Braddons Hills; but there is no means of proving this, as the same horizon may be massive in one place and distinctly bedded in another. Each mass of any magnitude consists of different horizons brought irregularly to the surface by faults and contortion.

Braddons Limestone.—The Braddons Hill limestone is locally made up of corals. This character is well shown in exposures by the winding ascent to Braddons Street, where *Heliolites porosus, Favosites* (*Pachypora*) *polymorpha,* and probably *Striatopora denticulata* were recognised. (The rock on the west side of Petit Tor Knoll exhibits a similar character.). The limestone is stained reddish in places, and splits occasionally in a somewhat irregular shaly manner.

In the quarry on Stentifords Hill, bluish-grey and pale grey limestones, in beds of from five inches to a foot in thickness, exhibit zigzag contortion. In the southern part of the quarry pale grey compact limestones occur in a way suggesting a faulted anticline. At their faulted junction with the Lower Devonian shales and grits, in Market Street, the pale grey limestones are distinctly bedded, but so broken that contortions cannot be traced with certainty. The fault, which is well shown by the steps on either side of the street, has a normal hade. Near the Castle thick even-bedded limestones are associated with thin and shaly beds. These dip in a north-westerly direction, and may denote the proximity of the inverted anticline of Eifelian slates, which separates the Braddons and Waldon Hill limestones from the Tor Hill Road mass.†

Waldon Hill.—The Waldon Hill limestones are exposed in cliff sections by Rock Road and Warren Road, where they are, for the most part, pale grey, more or less compact in texture, massive or thick bedded, and broken up by numerous irregular joints. Behind Abbey Crescent, the cliff seems to be a slickenside, along a faulted junction with the New Red rocks. In the Rock Walk cliffs the limestone is much plicated. Near Cumper's

* The Asheldon Copse and Kent's Hole limestone may belong in part or altogether to the upper beds, or be lower in the series.

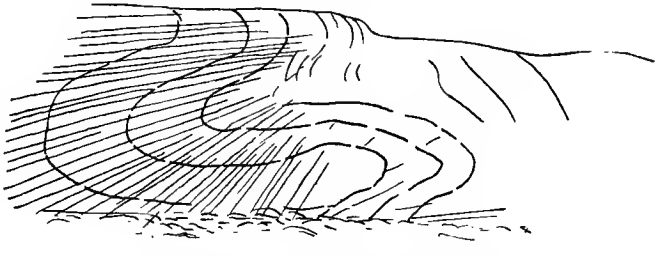
† The adjacent section near the Coffee Tavern at the north end of the Waldon Hill limestone has been referred to on p. 60.

Hotel, thick beds of slaty grey and reddish limestone (recalling the contorted limestone in the cliff on the west of Redgate Beach) dip toward the road below, so steeply that there is danger of masses of the rock becoming detached and falling.

The red colours of the limestones in White's account of the Brewery Well, describe a phenomenon met with, locally, both in the Middle Devonian and in the Eifelian limestones, and as the texture is in both cases similar, it constitutes a difficulty in distinguishing horizons where the exposures are insufficient to afford conclusive evidence. As bearing on this point, the locality depicted in Fig. 2, p. 12 is selected.

Wallshill.—Toward the south end of Redgate Beach, the cliff, facing east, consists of reddish or reddish-brown slaty limestone. The bedding is shown by a thick bed exhibiting a fine uniclinal plication (Fig. 10). The cleavage is evidently the result of con-

FIG. 10—NEAR THE SOUTH END OF REDGATE BEACH.



tortion, and near the top of the cliff there is an appearance of thin vertical bedding. The curve may be intersected by a fault. The cleaved limestone is probably subordinate to the massive grey limestone which forms the cliff near by on the north.

Where the cliff rounds toward Long Quarry Point, the massive grey limestones are (as previously mentioned) breached by two faults between which red shaly limestones, taken as Eifelian, are wedged in. These faults coalesce on Wallshill Down at a few chains from the cliff edge. Following their direction to the coast northward, the massive compact grey limestones of Shelter Cove seem to be much contorted, although persistent lines of bedding are not displayed. In a quarry west of Shelter Cove, reddish shaly crinoidal limestones are exposed under massive grey limestone, and are cut off by faults on either side. These shaly beds may be the top of the series of bedded limestones represented by the contorted bed in Redgate Beach cliffs. If Eifelian, massive limestones would, here, represent the whole of the Middle Devonian. This idea is, however, hardly consistent with the fact that the Wallshill limestones give place to bedded limestones towards Bishopstowe and Babbacombe. The exact relations of the Wallshill limestones to the Babbacombe Cliff limestones which are lower in the series, and to the red slates at the Cary Arms, which may be Upper Devonian, are not clear, and are, no doubt, obscured by faults.

Anstey's Cove and Ilsham.—In Anstey's Cove Upper Devonian slates, with representatives of the shaly *Goniatite* limestones, on either side, form a syncline separating the massive grey limestones of Ilsham and Devil's Point. The Ilsham limestones and the two patches on the south and south-east are often clearly bedded.

Asheldon Copse and Kent's Hole.—The slopes of the Ilsham and Asheldon Copse limestones are separated by a narrow tract of flat ground, suggestive of slate, which is in line with the north and south faults in the Redgate Beach cliffs, so these limestones are either on the same horizon, or, the Asheldon and Kent's Hole limestone is below that of Ilsham, and may even roughly correspond to parts of the Daddy Hole, Stantaways Hill, Torre College, etc., limestones. The quarry near Kent's Hole displays pale grey limestones in rather thick even beds dipping northward. A smaller quarry on the opposite side of the road presents an appearance of lenticular bedding, probably due to the intersection of an axis of uniclinal plication. *Actinostroma stellulatum*, Nich., obtained in this quarry, was somewhat doubtully identified by the late Prof. Nicholson, owing to distortion. He described the form as "abundant in the Middle Devonian of the Eifel (Gerolstein and Gees)." It occurs in the Dartington limestone. In the north of Asheldon Copse the limestones dip eastward at 26°.

Petit Tor.—Petit Tor Combe,* like Anstey's Cove, is a syncline of Upper Devonian slates, the grey and massive limestones on either side (Petit Tor Knoll on north, Petit Tor Hill on south) being in contact with traces of the shaly Upper Devonian *Goniatite* limestone. Petit Tor is a knoll of coralline limestone (recalling the Braddons Street limestone), and of pale grey limestone broken into large irregular blocks by uneven joints, and ramified by the peculiar fibro-crystalline form (organic ?) of carbonate of lime, to which Mons. E. Dupont applied the name "*Stromatactis*." The limestone forms a cliff overlain by New Red, which it separates from the Upper Devonian slates. The cliff attenuates to a mere shell, or wall, terminating on the beach in a pinnacle of broken rock, interpenetrated throughout with New Red material.

Petit Tor Hill.—Petit Tor Hill, the southern wing of the synclinal, has an appearance of horizontal bedding, due, apparently, to crush planes consequent on sharp zigzag foldings. Here and there, masses of slaty reddish limestone, quite distinct from the massive grey rock, seem to have been dovetailed in at these axial crush planes. On the beach the evidences of crushing and distortion are so great that masses of the grey limestone have been jammed into the slates. *Stromatactis* is not so frequent in this limestone. It is faulted against the New Red of the Oddicombe Beach cliffs on the south. Near Petit Tor Point, the grey limestone is exposed in Petit Tor Quarry. Here also red shaly limestones occur, as if lenticular in the grey rock, either natu-

* See Fig. 15, p. 109.

rally, or through the dovetailing of a contiguous rock by contortion. In this rock large specimens of *Orthoceras* have been obtained in considerable numbers. The researches of the marble vendors have made the quest for these organisms somewhat unprofitable. In polished specimens the structures are well shown in a matrix of deep red marble.

It will be seen that, from their relations, the limestones of Anstey's Cove and Petit Tor are the counterparts of the Lower Dunscombe limestone (in sheet 339) and, therefore, are homotaxeous with the *Rhynchonella cuboides* beds.

Lummaton.—The Lummaton limestone is bounded by New Red rocks on the north and west. It is well exposed in the quarries on Lummaton Hill and consists for the most part of a pale grey or dove-coloured, finely crystalline, massive, coralline limestone, in which *Smithia Hennahi* is conspicuous. The rock appears to be partly dolomitic in the western quarries. In the large eastern quarry rubbly, broken, shelly limestone occurs in one or two places, extending from the surface at the top of the quarry, irregularly downward for a few feet, in the more massive rock. Mr. Whidborne* describes it as "apparently little else than a shell-heap, and which was probably a local and littoral deposit. This would explain the fact that the Trilobites are almost always found there in a fragmentary condition; for most likely they had decayed and fallen asunder before they reached the place of deposition." In another place† in notes on *Hemitrypa oculata*, Phill., he observes," Judging from the general facies of the Lummaton fauna, it did not inhabit deep water, and was exposed to the action of strong currents and tides." Thanks to Mr. Whidborne's labours the fauna of Lummaton, principally obtained from the shelly part of the limestone, is more prolific than any heretofore described from any part of the South Devon limestones.

Toward Hele the massive Lummaton limestones give place to a distinctly bedded rock. On Windmill Hill, south of Hele, the limestone, although rather flaky, may belong to the uppermost horizons, which it resembles in texture. The extreme restriction of the shelly limestone to Lummaton may possibly be more apparent than real,but no such rich shelly material has been hitherto detected elsewhere in the Torquay limestones. From the following list taken from Mr. Whidborne's monograph, it will be seen that the numbers of *Stringocephalus Burtini* and of *Rhynchonella* (*Wilsonia*) *cuboides* (which were for the most part obtained in the shelly material), deprive these forms of any real value in determining horizons in the upper part of the South Devon limestone masses.

List of Fossils from Lummaton.

(For convenience of reference the order and nomenclature of Mr. Whidborne's Monograph are followed).

The specimens of doubtful derivation, but which, from the nature of the matrix, may have come from Lummaton have been

* Pal. Soc., 1889. Whidborne's Monograph, p. 2.
† Pal. Soc., 1895. Monograph, p. 180.

omitted from the following list. The numbers in brackets after certain fossils denote the number of specimens collected.

Trilobita 17, Phyllocarida 1, Ostracoda 9, Entomides 2, Cephalopoda 16, Gasteropoda 48, Lamellibranchiata 30, Brachiopoda 72, Discina 1, Crania 1, Bryozoa 14, Echinodermata, 10.

Trilobita.

Phacops batracheus, *Whidb.*
Cheirurus Pengellii, *Whidb.*
C. Sternbergii? *Boeck.*
Acidaspis Robertsii, *Whidb.*
A. pilata, *Whidb.*
Lichas Devonianus, *Whidb.*
Cyphaspis ocellata, *Whidb.* (common).
Proëtus batillus, *Whidb.* (common).
P. subfrontalis, *Whidb.*
P. Champernowni, *Whidb.*
P. audax, *Whidb.*
Harpes macrocephalus, *Goldf.*
Bronteus delicatus, *Whidb.*
B. tigrinus, *Whidb.*
B. pardalios, *Whidb.*
B. alutaceus, *Goldf.*
B. granulatus, *Goldf.*

Phyllocarida.

Tropidocaris? sp.

Ostracoda.

Cypridina? 3 sp.
Cypridinella cæca, *Whidb.*
Cypridella?
Polycope simplex, J. and K.
P. Devonica, *Jones.*
P. „ var. major.
P. „ var. obliqua.
P. „ var. concinna.
P. Hughesiæ, *Whidb.*

Entomides.

Entomis peregrina, *Whidb.*

Cyprosinidæ.

Cyprosina Whidbornei, *Jones.*

Cephalopoda.

Goniatites fulguralis, *Whidb.*
G. Hughesii, *Whidb.*
Trochoceras pulcherrimum, *Whidb.*
Gyroceras tredecimale, *Phil.*
G. Leei, *Whidb.*
Cyrtoceras lineatum, *Goldf?*
C. Robertsii, *Whidb.*
Phragmoceras? ungulatum, *Whidb.*
Gomphoceras poculum, *Whidb.*
Actinoceras devonicans, *Whidb.*
Orthoceras eutrichum, *Whidb.*
O. Robertsii, *Whidb.*
O. Vicarii, *Whidb.*
O. „ var. eductum.
O. oryx, *Whidb.*
O. cf. acuminatum, *Eichwald.*

Gasteropoda.

Macrochilina subcostata, *Schloth.*
M. subimbricata, *D'Orb.*
M. elevata, *Whidb.*
Loxonema Rœmeri, *Kayser.*
L. priscum, *Münster.*
Littorina Ussheri, *Whidb.*
Natica? nexicosta, *Phil.*
Platystoma sigmoidale? *Phil.*
P.? deforme, *Sow.*
Capulus? invictus, *Whidb.*
C. pericompsus, *Whidb.*
C. rostratus? *Trenkner.*
C. compressus, *Goldf.*
C. puellaris, *Whidb.*
C. terminalis, *Whidb.*
C. uncinatus, *F. A. Röm.*
C. columbinus, *Whidb.*
C. squamosus? *Trenkner.*
C. tylotus, *Whidb.*
C. galeritus, *Whidb.*
C. contortus? *F. A. Röm.*
C. multiplicatus, *Giebel.*
Orthonychia costata, *Barrois.*
O. quadrangularis, *Whidb.*
Holopella tenuisulcata, *Sandb.*
H. duplisulcata, *Whidb.*
H. Hennahiana, *Sow.*
Philoxene philosophus, *Whidb.*
P. lævis, *d'Arch and de Vern.*
P. serpens, *Phil.* rather common.
Euomphalus Dionysii, *de Montf.*
E. Hecale, *Hall.*
E. circularis, *Phil.*
E.? araneifer, *Whidb.*
Phanerotinus militaris, *Whidb.*
Rotellina? helicina, *Münst.*
Pleurotomaria subclathrata, *Sdb.*
Pl. impendens, *Sow.*
Pl. Orbigniana, *d'A.* and *de V.*
Pl. trochoides, *Whidb.*
Pl. subimbricata, *Whidb.*
Pl. Shaleri, *Whidb.*
Pl. delphinuloides, *Schloth.*
Pl. victrix, *Whidb.*
Pl. Bischoffii, *Goldf.*
Bellerophon lineatus, *Goldf.*
B. mundus, *Whidb.*

Chitonidæ.

Helminthochiton papilio, *Whidb.*

Lamellibranchiata.

Allorisma dubium, *Whidb.*
Cypricardinia scalaris, *Phil.*
C. striatissima, *Whidb.*
C. reticulata, *Phil.*
C. ensiformis, *Whidb.*
Conocardium clathratum, *d'Orb.* common.
Con. pugnans, *Whidb.*
Con. Villmarense, *d'A.* and *de V.*
Con. frater, *Whidb.*
Protoschizodus ? trigonellus, *Whidb.*
Nucula Protei, *Münst.*
Myalina luna, *Whidb.*
Gosseletia ?
Plethomytilus retrorsus, *Whidb.*
Rutotia elliptica, *Whidb.*
Actinopteria ? Robertsii, *Whidb.*
Act. hirundella, *Whidb.*
Act. dilatata, *Whidb.*
Act. placida, *Whidb.*
Act. Justi, *Frech.*
Act. Wurmii, *F. A. Röm.*
Act. rudis ? *Phil.*
Act. texturata, *Phil.*
Act. crenatissima, *Whidb.*
Pterinopecten gracilinus, *Whidb.*
Pt. Cybele, *Barrande.*
Pt. consolans, *Barrande.*
Aviculopecten aviformis, *Whidb.*
Lyriopecten fibratus, *Whidb.*
Crenipecten ? comma *Whidb.*

Brachiopoda.

Magellania Whidbornei, *Dav.*
Mag. sp.
Mag. juvenis, *Sow.*
Centronella virgo, *Phil.* (common).
Meganteris inornata ? *d'Orb.*
Stringocephalus Burtini. (25).
Enantiosphen Vicaryi, *Dav.*
Merista plebeia, *Sow.*
Athyris Glassii, *Dav.*
Ath. concentrica, *Von Buch.* (71).
Ath. Newtoniensis ? *Dav.*
Bifida Huntii, *Dav.*
B. ? plana, *Whidb.*
Retzia longirostris, *Kayser.*
Spirifera Verneuilii, *Murchison.*
Sp. subcuspidata ? *Schnur.*
Sp. undifera, *F. Röm.* (73).
Sp. concinna ? *Hall.*
Sp. nuda, *Sow.* (68).
Sp. curvata, *Sow.* (175).
Sp. infima, *Whidb.*
Sp. simplex, *Phil.*
Spiriferina insculpta, *Phil.*
Cyrtia ? Whidbornei, *Dav.*
Cyrtina heteroclita, *Defrance.*
Cyrt. „ var. multiplicata, *Dav.*
Glassia Whidbornei, *Dav.*
Atrypa reticularis, *Linn.*
A. desquamata, *Sow.*
A. aspera, *Schloth.*
A. flabellata, *Goldf.*
Pentamerus brevirostris, *Phil.* (142).
P. biplicatus, *Schnur.*
P. sublinguifer ? *Maurer.*
Conchidium britannicum, *Whidb.*
Stricklandinia ?
Rhynchonella acuminata, *Martin.*
Rh. reniformis, *Sow.*
Rh. pugnus, *Martin.*
Rh. triloba, *Sow.*
Rh. triloboides, *Whidb.*
Rh. parallelopipeda, *Bronn.* (138)
Rh. implexa, *Sow.* (56).
Rh. angularis, *Phil.*
Rh. ? anisodonta, *Phil.*
Rh. ? Ogwelliensis, *Dav.*
Rh. (Wilsonia) cuboides, *Sow.* (106).
Rh. (Wilsonia) omega, *Whidb.*
Camarophoria ascendens, *Stein.*
C. protracta, *Sow.*
C. Lummatonensis, *Dav.* (91).
C. ? rhomboidea, *Phil.*
C. Phillipsii, *Dav.*
C. cf. megistana, *Le Hon.*
Skenidium areola, *Quenst.*
Orthis striatula, *Schloth.*
O. ? sp.
O. Eifeliensis, *de Vern.*
O. pulcherrima, *Whidb.*
Orthotetes umbraculum, *Schloth.*
O. distortus, *Barrande.*
Strophomena rhomboidalis, Wilckens. var. analoga, *Phil.*
Stropheodonta nodulosa, *Phil.*
S. irregularis, *F. Röm.* (1).
S. interstrialis, *Phil.* (70).
S. ? nobilis, *M'Coy.* (13).
Productella subaculeata, *Murchison* (33).
P. fragrina, *Whidb.*
P. sp.
Chonetes ? Hardrensis ? *Phil.*
C. Phillipsii ? *Dav.*
C. convolutus ? *Phil.*
Discina peltastes, *Whidb.* (1).
Crania proavia, *Goldf.* (1).

Bryozoa.

Fenestella fanata, *Whidb.*
F. delta, *Whidb.* (1).
F. arthritica, *Phil.*
F. sp.
F. subrectangularis, *Sandb.*
Polypora populata, *Whidb.*
P. pagana, *Whidb.*
Hemitrypa oculata, *Phil.*

Bryozoa—cont.
Isotrypa? Gregorii, *Whidb.*
Diplopora pristina, *Whidb.* (1).
Ptilopora?
Penniretipora.
Ramipora.
Batostomella oomorpha, *Whidb.*

Echinodermata.
Hexacrinus interscapularis, *Phil.* (20).
H. perarmatus, *Whidb.*
H. ornatus, *Goldf.*
H. quintangulus, *Whidb.*
H.? aberrans, *Whidb.*
Thylacocrinus?
Rhipidocrinus crenatus? *Goldf.*
Haplocrinus decipiens, *Whidb.* (1).
Cupressocrinus Schlotheimi, *Stein.*
Sphærocrinus geometricus, *Goldf.*

The limestone of Lummaton is, like that of Barton (near it on the north), a coralline growth, and was doubtless a part of a reef which included the massive limestones of Petit Tor, Ilsham, Wallshill, etc. In the Upper Devonian slates of Anstey's Cove, near their junction with the massive limestone of Devil's Point, there are suggestions of the occurrence of similar tuffs to those of St. Marychurch. Again at the northernmost point of Blackhead similar tuffs seem to be associated with shales and *Goniatite* limestone resting upon 20 to 30 feet of compact pale yellowish and grey finely crystalline limestone containing *Alveolites, Cyathophyllum cæspitosum,* and *Stromatactis.* This mass rests, or is overthrust, on schalsteins containing numerous pieces of similar limestone in the uppermost part, and impersistent bands and nodules of limestone below. In this section we have, I think, the evidence of the dovetailing of the uppermost part of the limestone reefs with volcanic materials, which, in incursions from local centres of vulcanicity, interrupted the coral growth at different stages, and in parts of the area prevented the formation of limestone altogether. The tuffs in the Eifelian of Hope's Nose, etc., in the Middle Devonian of St. Marychurch, and those in the earlier stages of the deposition of the Upper Devonian of the Black Head are comparatively feeble evidences of contemporaneous vulcanicity in comparison with the districts yet to be described.

Brixham and Yalberton District.

The Brixham limestones form by far the largest and most continuous mass in the area. The Upper Devonian slates of Ivy Cove (with the Büdesheim fauna) are in inverted junction with the upper beds, whilst the lower are seen to rest on the Eifelian slates of Mudstone Bay. Consequently all the horizons of the Torquay limestones are represented. Massive or thick bedded limestones corresponding to those of Wallshill, etc., are encountered in the northern part, and bedded limestones corresponding to those of Daddy Hole, Babbacombe, etc., in the southern part of the mass. The anticlinal structure of Mudstone Bay was figured by Champernowne, and the superposition of the plicated limestone on the volcanic rocks of Sharkham Point was beautifully illustrated. This southern wing of the anticline is, as we have seen, in faulted junction with the Lower Devonian.

The Sharkham Point Iron Mine is in a mass of red and purple brown rock, brecciated with slate fragments in places, exhibiting

a wavy linear structure probably denoting bedding, and containing masses of hæmatite. This mass appears to be an anticline of the peroxidated volcanic rocks of the Sharkham Point shore, which invertedly underlie the limestone and are associated with slates. The same material appears to separate the limestone of Sharkham Point from that of Higher Brixham, but the relations of the Higher Brixham, to the Laywell limestone (which contains corals resembling *Clathrodictyum* and *Spongophyllum*) are not clear. From Laywell House westward volcanic rocks, apparently red and grey sheared lavas and tuffs and slaty diabase, occupy the position which we might expect the Sharkham Point limestones, if they had been persistent, to occupy. These volcanic rocks belong to the earlier eruptions of the Ashprington volcanic series, with which their continuity is only broken by denudation acting on the faulted area of Eifelian slates west of Lupton House. The anomalous position of the rocks on either side of the Mudstone Bay anticline is therefore due to the irregular incursion of volcanic materials on the margin of an area where limestone accumulation was in its earliest stages; so that the coral growth took place partly on the muddy bottom, partly overlapped the fringes of the earlier volcanic emissions, or formed banks against them. Between Waddeton, Yalberton, and Goodrington similar effects were produced by later eruptions emanating from local foci. Here, however, the relations of the rocks are rendered extremely complex by faults, and by the soluble character of the limestone surface. The largest tract of volcanic materials in this part of the area will be referred to as the Crabs Park volcanic district. As the consideration of the volcanic rocks involves a reference to the relations of the Upper Devonian they will be mentioned last in the following notes.

Eifelian Slates.

These slates extend westward from Mudstone Bay to the border of the map, their continuity being only broken south of East Cornworthy, where volcanic rocks are in faulted contact with the Lower Devonian. They also extend from Galmpton Creek to Port Bridge, and are brought up by fault near Stoke Gabriel, perhaps also forming a narrow strip on the north of that village. On either side of Mudstone Bay, more especially on the south, there are evidences of contortion where the slates pass up into the limestone. The transition is marked by red slaty and shaly limestone intercalated in beds and lenticles in red and lilac slates, which are, apparently, mixed with fine volcanic dust, on the south side of the bay, where *Phacops ? macropthalmus* (according to Whidborne) and a large coral resembling *Cyathophyllum bilaterale* were obtained. In the corresponding beds on the north side of the bay Champernowne * recorded the discovery of two corals, viz., *Zaphrentis calceoloides* ? and *Campophyllum* ?. Grey buff-weathered slates succeed these

* *Quart. Journ. Geol. Soc.*, vol. xl., Aug. 1884, pp. 497–499, pl. xxi.

intercalated beds and, in the centre of the anticline, seem to rest on dark grey slates with irregular lenticular brown-weathered bands of slaty limestone containing Cephalopods. These latter are the beds from which *Cyrtoceras bdellalites*, Phill., and *Gyroceras ornatum*,* Goldf. were obtained. The slates of Mudstone Bay have also yielded *Athyris concentrica*, *Streptorhynchus umbraculum*?, *Cyathocrinus pinnatus*, Goldf., *Gorgonia repisteria*, Goldf. (*Polypora populata*? Whidborne), *Spirifers* and *Zaphrentids*. Champernowne † figured *Zaphrentis Mudstonensis*, which he obtained in the grey slates. The *Cyrtoceras* fauna seems to occur in the lower parts of this slate series which have yielded no fossils at Meadfoot Sands and Hope's Nose. Taken in connection with the doubts as to the representation of the Lower Devonian by slates in its uppermost beds, expressed in the footnote on page 42, the occurrence of a Cephalopod fauna in the lower part of the slates under the limestone developments is suggestive of a representative of the *Orthoceras Schiefer* in South Devon. This is, of course, merely a tentative suggestion, and even if it should ever be proved correct, it would not be possible to draw any line with an approach to stratigraphical accuracy in the slates which represent the Eifelian slate group. At Laywell House, not far from the limestone patch, a well was sunk to a depth of sixty feet in the slates. At Lupton Farm there are grey and lilac slates; the grey slates contain fossils. Other places where indications of fossils were observed, usually in a very bad state of preservation, are as follows:—Higher Alston, crinoids; west of Higher Alston, south of Widemoor Barn; south-west and west-south-west of Higher Alston, at about thirty-two chains distance, traces of *Spirifers*, crinoids, and *Pleurodictyum*? were noticed; south of Higher Greenway, very badly preserved fossils; Dittisham Waterworks, near Lower Devonian, south of Higher Dittisham; south of Foxhole Copse and in a slate (Berry Park type) quarry in Bullcombe Wood, and between Kingston and Downton Wood, where *Spirifera* and *Streptorhynchus* were recognised in partly calcareous slates. The Ashprington series here interrupts the outcrop. West of Combe crinoids are met with; the slates assume the Berry Park type in places. By Woodland Lane they have been quarried out in large flaggy blocks and are occasionally fossiliferous. Near Gitcombe, north-west of Higher Tideford, the slates contain fossils; also, near Grant's Hill Plantation, Lower Washbourne, and Higher Washbourne. The slates between Waddeton and Port Bridge occasionally present the Berry Park type, but more often resemble those of Mudstone Bay and Ellacombe. Brachiopods including *Streptorhynchus* occur in them on the west of Waddeton, and on the east of Port Bridge *Phacops* and an *Orthis*, near to *O. Eifelense* (according to M. M. Gosselet and Barrois) were noticed and *Phacops* cf. *latifrons* (according to Herr Frech).

* Whidborne, Pal. Soc., 1890, p. 95.
† Champernowne, op. cit. p. 502, pl. xxiii.

Limestones.

The Brixham limestone, notwithstanding frequent appearances of nearly horizontal bedding, is much contorted and, as shaly and slaty structures have been frequently developed, in the absence of distinctive fossils, it is often impossible to distinguish Eifelian limestones from higher beds. Between Durl Head and Mudstone Bay a strong cleavage dipping south-east traverses limestones dipping north-west. In the cliffs between Berry Head and the Mew Stone slaty limestones are contorted in the cliff. At, and near, Galmpton shaly Eifelian limestones are probably repeated by folds. At Churston Station red shaly limestones contain *Cyathophyllum cæspitosum, Favosites Goldfussi, Heliolites porosus.* At Galmpton Quay, on the south of the shipbuilding yard, the section corresponds more or less to those of Daddy Hole and Hope's Nose. Grey and dark grey very irregular limestones, with *Heliolites porosus,* show occasional brown earthy decomposition products and rest on irregular red slates with crinoids and lenticles and thin beds of limestone—the whole forming a passage from limestone to slate. By the Dart near Waddeton Boat House Quay the junction beds consist of red slates, intersected by quartz veins in places and much disturbed, with red concretionary nodules and irregular lenticular peroxidated limestones containing badly preserved corals amongst which *Favosites Goldfussi* is recognisable. Both here and at Waddeton the rocks locally assume the character of mudstones traversed by a fine secondary cleavage and splitting in prismatic fragments. Brachiopods, Crinoid ossicles, and traces of *Fenestella* occur in the slates.

The Brixham mass is evidently cut up by faults, and, except on the coast line, exposures are not sufficiently numerous to enable one to detect them or to trace horizons.

At the paint works near Brixham Station compact, bluish, massive-bedded, shaly-splitting limestones have been dissolved into irregular potholes and fissures containing New Red sand and brecciated loam. Blocks of New Red sandstone are met with here and there on the limestone plain. West of Brixham Station similar limestone to the above is exposed; it is pale buff and brown, and exhibits a dolomitic aspect in places. In Waddeton, just south of the large New Red outlier, no limestone is actually visible *in situ.* This outlier is inferred from a red clay soil with blocks and pieces of sandstone; it seems to be a mere soil on red and lilac slates, which are evidenced round the isolated masses of limestone, and up to the sinuous boundary of the limestone east of Waddeton and north of Galmpton Warborough. Near Galmpton Warborough, and by the high road to Paignton (west of Broad Sands), the limestone has a dolomitic aspect; this character is still more pronounced in the isolated mass on which the two small outliers of New Red sandstone are shown, here the rock, as exposed in an old quarry, is of a drab colour and saccharoid appearance. Masses of iron ore, probably in potholes, have been worked in this patch. The red

slates in the irregular tongue which ramifies the limestone mass toward Galmpton are associated with felspathic tuffs. East of Waddeton Lane, and south of Crabs Park, red-lilac and purple slates are so imperfectly exposed that one cannot say whether they are associated with volcanic rocks or not, or tell their relations to the pale grey and pinkish compact limestone patches on the east side of Waddeton Lane. These limestones resemble the upper beds in the Broadsands railway cutting. As these slates are, either a replacement of the upper part of the limestone mass, or Upper Devonian, their proximity to, if not actual contact with, Eifelian slates at Waddeton can only be explained by the assumption that the limestone is almost cut out by faults at that hamlet. North west of Waddeton the Eifelian slates are bounded by limestone, the boundary of which is indefinite and its connection with the large Yalberton mass near it could not be proved; it is probably Eifelian. The limestone of the small outlier contains *Favosites Goldfussi*. The fossiliferous Eifelian slates of Port Bridge pass under the limestone on the north and east. At Castlepark Copse, near Lower Well Farm, the limestone is bounded by a nearly east and west fault, on the south of which a mass of limestone, partly thin bedded and slaty, partly dolomitized, occurs, probably in a syncline in the Eifelian slates.

The Yalberton limestone mass often exhibits a dolomitic appearance north of Higher Yalberton, and between Lower Yalberton and Aish. Between Aish and Stoke Gabriel, near its faulted junction with the volcanic series and a coralline limestone near Hoil,* compact grey limestone (partly dolomitic) is exposed. To the east of this, near an old shaft, dolomitic limestone has been dissolved into pipes and potholes filled with brown earth (umber ?). Further east, at Bitney Brake, there is a small outlier of New Red, and near it a red loamy soil is suggestive of the retention of overlying materials on an eroded limestone surface. The Yalberton limestone is doubtless a part of the same plain of Permian (?) denudation as the Brixham limestone, which would account for the sandstone fragments boulders, and other relics of the New Red found on the surface.

North of Lower Yalberton *Cyathophylla* and *Stromatopora* were noticed in the limestone. Near Brake Copse a bluish grey coralline limestone furnished *Paralellopora dartingtonensis*? Carter, identified by Nicholson.

The boundary of the limestone with the Crabs Park volcanic series, from Higher Yalberton southward, is very sinuous and marked by feature up to a point east of Brake Copse, but further south it is extremely indefinite, so much so that it is very possible that the limestone may unite the two small patches, shown on the map, with the irregular mass on the south. South and southwest of Brake Copse red slates, tuffs, and schalsteins occur, either in dissolved depressions in the limestone, or under them; in the latter case, it is possible that they may disconnect the

* See Chapter iv., p. 83.

limestone near Lower Well Farm from the main mass, due east of Well Farm.

The Crabs Park Volcanic Series.—North of Waddeton the volcanic materials are chiefly tuffs and schalsteins. Between Lower Yalberton and Crabs Park, and west of Eight Acre Pens Linhay the lavas are represented by local masses of vesicular rock. Near the last named place there is a cluster of patches of diabase; one of these may be a neck; it is surrounded by coarse tuffs associated with altered fossiliferous mudstone. There are suggestions of limestone bands near the Linhay. Between this and Crabs Park Cottages (near the tenth milestone from Newton, by the road) on the north, thick, blue-grey, indurated slates either occur in the volcanic series, or are folded up from beneath it. In these, *Orthis* and *Pentamerus* were recognised by Dr. Kayser. The tuffs in the vicinity are often very coarse. North of, and near Crabs Park Cottages there is a mass of diabase, and a small patch of limestone which is probably bounded by a north-west and south-east fault. Near Higher Yalberton Cottages the tuffs are partly felspathic, partly fine (with no visible felspar). The Crabs Park limestone seems to be partly dolomitic; its junction with the volcanic rocks is ill-defined, and the irregularity on the north is apparently due to faults. At Crabs Park the eastern boundary is faulted against red slates (Upper Devonian ?). This fault cuts off the southern end of the limestone, and further south appears to form the eastern boundary of the volcanic rocks. At half a mile north of Waddeton, indurated lilac mudstones containing *Atrypa reticularis* were observed on the border of the volcanic rocks. A narrow band (probably thrust or faulted) of schalstein separates the Crabs Park limestone from the Clennon Hill limestone on the north. The latter is a pale grey compact rock, which is seen in the easternmost quarry to be irregularly associated with buff, red-mottled mudstone.

Goodrington Volcanic Rocks.—In Champernowne's words,* "The next patch of volcanic rocks brings us to the coast of Torbay. It lies east of Goodrington, forming the 'sugar-loaf' hill, of less elevation than the limestone plateau to the south. A hard, aphanitic rock protrudes for a short distance along the top, but does not reach the railway cutting close to the cliff, where it is flanked by tuffs. This patch throws off some beds of iron-shot limestone to the north, dipping north and exposed in the cutting. The face of Saltern Cove is a north and south line of fault, which has shifted the iron-shot limestone on the foreshore south of its exposure in the railway cutting. . . . It abounds in corals — *Favosites cervicornis,* Edw. and H., *Alveolites* sp. *Cyathophyllum cæspitosum,* Goldf., and simple forms, *Stromatopora* crinoids, and, more rarely, *Acervularia* (sp.). The layers are parted by a red clay. At the foot of the cliff in the main

* On the Ashprington Volcanic Series, *Quart. Journ. Geol. Soc.* for Aug. 1889, p. 374.

cove the tuff exposed is identical with a piece of schalstein from Weilburg, Nassau, in my collection." The limestone above mentioned is the Feather-stone of the Torquay lapidaries. For distinction it will be referred to as the Upper limestone. It is overlain by the Upper Devonian *Goniatite* slates of Saltern Cove. The persistence of this limestone could not be proved through Goodrington, but it is visible on the west, where it is separated from the main mass by grey vesicular schalsteins, with which it is cut off by fault against a triangular tract of slates, bounded on two sides by the main limestone. Further west the north boundary of the main limestone is a fault. In a quarry by the high road at Goodrington the limestone is altered, overlain by tuffs, and in irregular junction with aphanite, apparently intrusive.

In its faulted continuation on the coast, the Upper limestone strikes from the cliff seaward, and curving southward is again visible in an isolated patch resting on the volcanic rocks (which are intersected by veins of calc-spar), and in bold, thick-bedded masses in the seaward reefs at the southern horn of the bay. Just south of the point the cliff is composed of bedded tuffs, with veins of calc-spar, and patches and nodules of limestone on the bed faces, and intercalations of slate. Further south, in a small cove, the tuffs rest on red mudstones and slates interstratified with tuffs, beneath which is a boss of limestone, perhaps the top of the underlying mass. Further on, the volcanic rocks, probably repeated by fault or folding, form the cliff, and are seen to rest on red mudstones with limestone lenticles, mostly coralline. A mass of calc-spar marks the fault junction of these beds with the main limestone. This calc-spar represents the Upper limestone between two faults, viz., the fault boundary of the main limestone and a fault coincident with the trend of the coast, bounding New Red in the beach reefs and promontory, and cutting off the Goodrington Park limestone on the east.

The Goodrington Park limestone is faulted against slates on the south. It consists of blue-grey, irregularly-cleaved beds, separated by films of red mudstone, and is, I think, the representative of the Upper limestone. It rests, nearly horizontally, on red mudstones associated with fine tuffs, and these, in their turn rest on the main limestone, which forms the steep slopes of the valley spanned by the railway viaduct. From the viaduct northward the railway cuttings give the following section:—For four chains, compact grey and pinkish bedded limestone. Fault crack filled with New Red *débris*, and throwing down red mudstones, vesicular and indurated in places, associated with tuffs, and red slates with irregular masses of limestone and calc-spar in places: these beds occupy the cutting for five or six chains, and rest on compact grey and pinkish limestone containing *Stromatopora*, and exhibiting a tendency to flake off in shaly pieces. At four chains from their outcrop there is an appearance of disturbance, and at a chain further, irregularly bedded pink and grey limestones with dog-tooth spar overlie, or are faulted against, pale grey, more or less massive limestones rich

in *Stromatopora*. Near their faulted junction with the Goodrington volcanic rocks, at eight chains further north, a lenticular slaty patch is noticeable in the limestone. (Compare Clennon Hill Quarry.)

In this section the limestones correspond to beds in the upper part of the Brixham mass, and to the Ilsham etc. limestones of Torquay; and the red mudstones faulted down are probably a repetition of those beneath the Goodrington Park limestone, and therefore representatives of the Goodrington volcanic series. Near its western extremity, where it is separated by volcanic rocks from the south end of the Crabs Park limestone, the main mass is dolomitic, as also in a large quarry near the high road at about half a mile south of Goodrington. Near Hookwells the limestone resembles that of Goodrington Park, and is bounded on the west by a faulted patch of volcanic rocks with diabase.

Along its very sinuous boundaries the main limestone is, no doubt, faulted in many places against the red and lilac slates on its flanks. These slates are seldom well exposed. South of Hookwells, they are associated with fine volcanic breccia and tuffs rich in felspar fragments. On the east of Galmpton Warborough turnpike; south of Elbury; in the faulted tongue on the Brixham limestone south and east of Silver Cove, and at Fishcombe Cove, the slates also contain red tuffs or schalsteins.

The Elbury limestone forms Galmpton Point (not named on the 6-inch maps). This limestone is composed of thin and fairly thick beds, separated by red mudstone, and repeated by innumerable small inverted plications. *Alveolites suborbicularis*, and other corals occur here. There is every reason to regard this limestone as equivalent to that of Saltern Cove and Goodrington Park, but the age of the slates on the south side of it has not been proved by fossil evidence, although we have near it on the coast the Upper Devonain red slates with *Goniatites*.

Comparing the Goodrington with the Black Head section, the succession is identical, although the Upper limestone differs in character, being a massive bed. *Goniatite* slates on limestone on schalstein is the sequence in both cases—but at Ilsham the *Goniatite* beds are in direct contact with the limestone mass, just as they appear to be near Silver Cove in inverted contact with the Brixham limestone. Moreover, there are signs of vulcanicity in the Upper Devonian above the *Goniatite* beds between Ilsham and Black Head, if indeed the Black Head diabase is not itself a lava plug. It appears, therefore, that the Upper limestone is an impersistent coral bank on volcanic rocks at Black Head; the coral growth being interrupted by repeated incursions of fine mud in the Saltern Cove, Goodrington, and Elbury limestones —and that sporadic showers of ash may have accompanied, or succeeded, the deposition of the Upper Devonian *Goniatite* mudstones in both places. The local eruptions which preceded the formation of the coral bank rendered the bottom on their margins unfit for coral growth by the extension over it of volcanic mud, or of muddy sedimentation; and, whilst all these events were taking place, in contiguous, but favourable, sites, the

reef growth went on uninterruptedly. This hypothesis will, I think, explain the various phenomena displayed in the district south of Goodrington and west of Brixham. When the Upper limestone is absent, without fossils, it is obviously impossible to distinguish slates with occasional schalsteins or tuffs, which represent a stage of limestone in the upper part of the main reefs (such as those underlying the Goodrington Park limestone), from Upper Devonian slates with tuffs (such as the faulted band south of Ivy Cove is considered to be). There are schalsteins, probably Upper Devonian, at Fishcombe Cove, where the following fossils, identified by Professor Frech, were found in the upper part of the underlying limestone.

Alveolites suborbicularis, *Bl.*
Petraia decussata, *Münst.*
Cyathophyllum heterophylloides, *Frech.*

The Crabs Park volcanic series represents a much more extended period of local vulcanicity than that of Goodrington. The earliest eruptions may have begun shortly after the earliest stage in the formation of the Eifelian limestone, and the later ones may (as far as one can judge) have been coeval with those of Goodrington. The presence of fossiliferous mudstones, and of small limestone patches in the volcanic rocks, may be accounted for by intervals during which ordinary sedimentation was resumed. The transition from volcanic rocks, on the west, to red and lilac slates, on the east, may be due to the tailing off of the coarser volcanic ejectamenta in mud, etc., as in the case of the Goodrington eruptions, but at earlier stages, and for a more protracted period, or periods.

It is not probable that the upper horizons of the Brixham limestone are represented in the mass between Yalberton and Stoke Gabriel. It corresponds, I believe, to the limestones of Vane Hill and Daddy Hole, Torquay, and is continued in part by the limestones of Aish, Lomentor etc. (which mark its extension on the borders of the Ashprington volcanic series) to the Berry Pomeroy, and through them to the Marldon limestones.

The contemporaneity of the eruptive rocks of the Goodrington and Crabs Park volcanic districts with volcanic rocks of the Ashprington series is, generally speaking, certain; but, although an actual mingling of eruptive materials from the different areas is extremely probable, it is not actually provable The limestones connected with the Ashprington eruptive area will be described in the next chapter.

CHAPTER IV

MIDDLE DEVONIAN—*continued.*

Ashprington Volcanic Area.

As a component of the Middle Devonian, the Ashprington* volcanic series is far more persistent than the limestones it replaces; as tuffs and schalsteins, coeval with part of it, practically connect the limestones of Brixham with those of Ashburton and Plymouth in a stratigraphical horizon.

The name given to this volcanic group is amply justified by the fact that nowhere in Devon and Cornwall is there an equal extension of volcanic rocks to that surrounding the village of Ashprington. This extension seems to be due, primarily, to a more protracted and continuous volcanic activity, the later stages of which were doubtless prolonged into the Upper Devonian, (coeval with the schalsteins and felspathic tuffs south of Goodrington), but the flattening of the Paignton anticline westward contributes to it, by the repetition of the same horizons in shallow curves. This area of maximum vulcanicity extends from Totnes to Stoke Gabriel, Dittisham, Cornworthy, and Harbertonford.

The volcanic rocks embrace tuffs, schalsteins, hard slaty diabases, and patches of diabase, which may be subsequent intrusions, or pipes by which the later eruptions reached the surface.

The tuffs and schalsteins are so sheared and decomposed that it is frequently impossible to distinguish a schalstein lava from a schalstein tuff. They exhibit a variety of colours such as buff, purple, green, etc., but the prevalent colour is a deep red in which small white (zeolitic) patches are often conspicuous. The peroxidated materials are well exposed in the following places:—Near Cholwell Cross; near Langridge Cross; near Bowden Pillars; between Bowden House, Sharpham Barton and Ashprington Cross; between Cross Lanes and Ashprington; south of Sharpham House and near Ashprington point, where they contain amygdules with ferruginous coating. On the opposite side of the Dart—south of Weston House, east of the Rifle Butts, near Fleet Mill, west of Longcombe, north-east of Millcombe Barn, north and west of Hackney Creek, near Duncannon, south and south-east of Stoke Gabriel. Buff tints prevail, near Redworth, near True Street, south of Totnes, north of Bowden House, near

* The term Ashprington Volcanic Series does not occur on the map, and as it really denotes a special area of maximum vulcanicity, the general application of the term to volcanic rocks of Middle Devonian age outside this area can only be used with propriety in a restricted sense.

Luscombe Cross, north of Ashprington Cross, near World's End, east of Millcombe Barn, etc. In many places red and buff beds are intercalated.

Hard diabases, whether contemporaneous or intrusive, are distinguished by the darker tint on the map. These are marked by bold crag features on the slopes of the hills, but are generally indistinguishable by feature on the summit, where many of the patches shown have been inferred from surface fragments only. Near Torcombe sheared slaty diabase and massive diabase make fine craggy features. The rocks have an apparent southerly dip. Hard slaty porphyritic diabases make a bold ridge near the Lodge south of Sharpham stile. Slaty diabase occurs at Dundridge, west of Langridge Cross. A hard vesicular diabase is quarried at Peak Cross, north of Ashprington Cross, and west of Sharpham Barton a mass of diabase runs north-east and south-west; it is bounded by grey-brown vesicular rock, shaly where weathered. Highly vesicular rock is associated with peroxidated tuffs at Sharpham Barton.

A small patch of aphanite and bluish vesicular slaty rocks occur in Higher Gribble Plantation. Rocks from a quarry, by the Dart, near the Rifle Range butts, and from Byter Mill east of Stoke Gabriel, were pronounced by Dr. Hatch to be sheared amygdaloidal diabases with flattened chloritic amygdules. Slaty vesicular diabases are met with at fifty chains north of Fleet Mill, south of Fleet Mill, and east of Hackney Barn. South of Port Bridge there are three bands of hard slaty diabase, apparently intercalated in the tuffs and schalsteins, the northernmost can be traced to Stoke Gabriel.

At Ham Barn, east of Sharpham Point, bluish amygdaloidal rocks strike nearly east and west. East of Sharpham House pale greenish-grey schalsteins have been quarried. Near the Boat house of Sharpham House the amygdules are filled with calc spar. On the east of Ashprington, green, slaty and vesicular, fragments of igneous rock are scattered over the brown arable land.

Sheared vesicular diabase (melaphyr) occurs on the south of Tuckenhay Paper Mills. In a similar lava north of Higher Dittisham the amygdules are filled with quartz.

Many of the diabase patches, indicated by surface stones or insignificant exposures, may cover larger or smaller areas than is shown on the map, such as the large mass at Luscombe Cross the patches north of Stancombe, between Ashprington and Ashprington Cross, etc.

Most of the smaller diabase patches are aphanites, of which the rock forming the Sharpham Reach promontory, by the Dart is a typical example. There are several patches near Harbertonford, by the Dart north of Sharpham Park, at Pen quarry near Stoke Gabriel, on the north of Fleet Mill where the rock is veined with epidote, near Redworth, etc. Porphyritic diabase patches are met with on the north of Totnes Cemetery, south-east of Follaton House, near Broomborough House, and on Harper's Hill west of the northernmost lodge in Sharpham Park, etc.

The following notes are by Dr. Hatch:—

E. 1105. Pit west of Sharpham Barton Linhay plantation—Compact diabase, slightly porphryritic, consisting of isolated porphyritic crystals of plagioclase embedded in an altered ground mass composed of augite, felspar, iron ore, and chlorite. The structure of the rock is much obscured by the turbid alteration products of the felspar.

1159. From a small patch, north-west of Sharpham House—Altered diabase veined with secondary minerals: quartz, epidote, chlorite, etc.

1158. Quarry near Ham Barn, Hackney Creek—Porphyritic diabase, rich in granular epidote and chlorite, resulting from the decomposition of augite and felspar; some iron ore.

E. 1106. Old quarry near Totnes Workhouse—Compact diabase slightly porphyritic, composed of small porphyritic crystals of felspar embedded in a ground mass of felspar and chlorite (the latter arising from the alteration of the augite). In the Chlorite are scattered numerous granules of titaniferous iron ore (ilmenite). Calcite in isolated patches.

E. 1108. Quarry by back road to Broomborough House, west of Totnes—Porphyritic diabase, much decomposed: plagioclase, chlorite, ilmenite, calcite, etc.

Hard compact buff rocks * occur in places in the volcanic series, as near Sharpham House boathouse, at Totnes Castle, near Dartan Moor (north of Bridgetown, Totnes), west of Redworth, etc. The specimen from Totnes Castle is thus described by Mr. Teall:—

3156. Totnes Castle—Compact rock mottled with pale greenish-grey and purplish tints. Weathers brown.

M. A few small phenocrysts of completely altered felspar in a matrix of similarly altered lath-shaped felspars; carbonates after augite and iron-ores.

1491. South of Dittisham Corn Mill.—A rock pronounced to be "ophitic dolerite" by Prof. Watts.

At Follaton House and in the lane south of Broomborough House there are whitish slates, of a steatitic aspect in the latter case. These may be of volcanic origin. Similar slate has been recorded in the Lower Devonian area near Bugford, west of Dartmouth. (See p. 39.)

Relations of the Volcanic Rocks.

No evidence of continuous intervals during which ordinary sedimentation took place has been obtained in the volcanic area, but some traces of slate may be accounted for by deposition between periods of eruption. Thus, bands of slate seem to be intercalated in the volcanic series in the following places:—purple slates at sixteen chains north of Langridge Cross; lilac slates east of Dundridge; a nearly north and south band of purple and buff slates east of Cholwell; a thin band of purple slate north of Cross Lanes, east of Ashprington; purplish slates between Lower Gribble Plantation, and Ashprington Cross. By the alluvium of the Dart, near World's End in Sharpham Park, ten feet of purple shales with traces of cherty limestone are exposed in the low cliff, and in a quarry by the avenue, fifteen chains south-west of it, purple slates in the volcanic rocks dip eastward at 15°. On the summit between Lower Longcombe and Millcombe

* Similar rocks occur in the volcanic series between Ugborough and Plymstock (Sheet 349).

Barn, east of Fleet Mill, there is an irregular patch of red, buff, and mottled slates, associated with quartz. Some buff slates overlying volcanic rocks in the valley on the north may be the continuation of this patch shifted by a north and south fault.

The above instances might perhaps be explained by the appearance of underlying sedimentary beds through faults and inverted plications, as in the following occurrences:—South of Totnes dark grey buff-weathered slates are exposed by the road near Gerston Cross, where they seem to be shifted by fault, and are seen to contain a little dark grey calc-veined limestone. Dark slates are also exposed by the road between Windmill Down and Tristford Cross; their extension towards Broomborough House is doubtful. At the end of a plantation, fifteen chains south-east from Follaton House, a small patch of limestone is met with; it is probably brought up by faults, accounting for springs which rise in the vicinity in the volcanic rocks. A small triangular patch of limestone, bounded by faults on the west and south, but apparently dipping under the volcanic rocks on the east, occurs on the hillside at thirty chains south from Weston House.

At Parkers Barn grey slates are exposed. They extend along the banks of the Dart for about eighteen chains, passing under volcanic rocks on the south (where they contain films of limestone) and east, and are cut off by a nearly east and west fault on the north. Following the direction of this fault eastward, on crossing the tributary valley south of Fleet Mill, it coincides with a tributary valley in which three tiny patches of limestone may be detected, at and west of Millcombe Barn. By the Fleet Mill valley, at eighteen chains east of Parkers Barn, a small limestone patch dipping under volcanic rocks on the south, is visible south of Hackney Barn. It is probably bounded by slates under volcanic *débris* on the north. A small, nearly circular, patch of limestone with south-easterly dip is noticeable at about a quarter of a mile north of Pen Quarry.

The boundaries of the volcanic rocks are not the fringes of the products of an eruption, or of a series of contemporaneous eruptions, from different vents, but of the emissions of many different eruptions taking place at different times and from different vents. There is, therefore, nothing anomalous in the different relations displayed by the volcanic rocks to the slates and limestones, as their boundary is traced round from Harbertonford to Totnes.

The absence of limestone along the southern boundary, except at Harbertonford (where a mass of dark grey slaty Eifelian limestone underlies the volcanic materials), is, perhaps, partly due to fault junctions with the Eifelian slates, as faults undoubtedly occur between Harbertonford and Washbourne, and near Combe, East Cornworthy, and Dittisham. The volcanic series is thus brought in contact with the Lower Devonian near Combe, and a great part of the Eifelian slates are cut out south of Dittisham.

In Champernowne's paper* "On the Ashprington Volcanic Series," the Greenway House coast from the Fishpond's inlet, near Greenway Viaduct, northward is thus described:—"Some grey slates with a few calcareous seams line the north side of this inlet and rising from below them a great mass of lavas and tuffs with some very hard rock forms the ledges until we round Greenway Quay and reach their base. Along the bank from here to near Galmpton Mill some beds of dark limestone and buff-coloured shale extend. They are exceedingly rich in corals, the prominent forms being *Alveolites compressa*? Edw. and H., large specimens of *Cyathophyllum damnoniense*, Phil., and others. *Cystiphyllum vesiculosum*, Goldf., also a specimen of *Hallia* occurred, the latter with a quantity of *Aulopora* hanging about it."

On the same side of the Dart, west of Waddeton Quay, the volcanic rocks are again encountered. They consist of red, purple, buff, and green lavas and tuffs, with occasional small masses of hard diabase. On the east they are bounded (apparently) by slates, but on the north limestone containing *Cystiphyllum vesiculosum* is encountered; the continuity of this limestone (as shown on the map) with that of Sandridge Park is inferred. South of Sandridge Park a quarry in grey coralline limestone afforded *Cyathophyllum cæspitosum* and *Cyath. helianthoides*. In parts the limestone is shaly, as by the Dart at Ladies Quay, where it is overlain by soft mottled fossiliferous shales, apparently fine tuffs. At Sandridge Point the limestones reappear under volcanic rocks partly fossiliferous, as above. Their junction with the limestone is irregular and ill-defined. Hard red crinoidal limestones are seemingly intercalated with the tuffs, and the dark-grey, red-weathered, lenticularly shaly limestones have soft red partings and bands. A volcanic breccia with limestone fragments is observable in one spot near hard diabase. The limestones yielded *Receptaculites*, *Alveolites compressa*, *Cyathophyllum* (possibly *C. obtortum*), *Strophodonta*? and *Zaphrentis*, kindly identified by Mr. Whidborne.

On the opposite bank of the Dart, a tiny patch of limestone is visible under the volcanic rocks at Redgate near Higher Gurrow Point. A similar patch of slaty blue and brown limestone (with *Cyathophyllum obtortum*) is met with at Blackness Point, near a band of slaty limestone with rugose corals, and gently undulating bedding (along the Dart shore). This band is repeated by plication along Dittisham Mill Creek. It reappears in the limestone patches of East Cornworthy which are shifted by fault on the west, and in a small patch on the southern margin of very fossiliferous grey Eifelian slates of the Berry Park type, exposed by the Dart. Recrossing the Dart between Stoke and Mill points, we again encounter the limestones, with occasional brachiopods and numerous corals, amongst which Mr. Whidborne recognised *Alveolites compressa*, *Cyathophyllum*

* *Quart. Journ. Geol. Soc.*, vol. xlv.
† Identified by Rev. G. F. Whidborne.

cæspitosum, *C. obtortum* (probably), *C. vermiculare*. These limestones are intermixed with buff material, and are in places much altered and decomposed. A chalcedonic film was observed in the decomposed brown rock. The connection between the limestone and volcanic materials is so intimate that the rocks display the appearance of schalstein-kalk in places. In one spot a hard, red rock, probably a peroxidated igneous dyke, seems to have penetrated the limestone. The rocks are evidently contorted. At the mouth of Bow Creek, south of Langham Wood Barn, there is a small patch of decomposed limestone and schalstein-kalk. On the south shore of Bow Creek, limestone underlies the volcanic rocks, forming two patches at from 20 to 50 chains east from Tuckenhay Creek. In the westernmost of these, thick bedded and slaty dark blue limestones are exposed, for about 50 feet, in a quarry.* They contain numerous corals amongst which Mr. Whidborne recognised *Cyathophyllum bilaterale*, Champ. In another part of the limestone, which occurs on the border of a small alluvial tract, *Spongophyllum* was noticed. East and south of Bow the bluish coralline limestones are again visible—by the creek in Crownley Wood under volcanic rocks—exposed to a depth of 20 feet in a quarry north of Crownley Wood, and between Lower Yatson and the River Harbourne. The connection between the two last exposures is inferred, along the strike of the limestone anticline. Near this between Bow, Beanleigh, and Luscombe, there is a considerable tract of Eifelian slates. Along its border limestone has only been proved to separate the slates from the overlying volcanic rocks in one place, viz., south of Torcombe, where there is a small patch of blue and greenish, irregular, slaty limestone, associated with slates and overlying slates of the Berry Park type.

Returning to the main boundary at Sandridge Park, we find the volcanic rocks, between that place and Port Bridge, bounded by Eifelian slates of the Mudstone Bay type. The junction appears to be an irregular north and south fault, throwing down the volcanic rocks on the west. North of Stoke Gabriel reddish and grey slates may separate the limestone mass from the volcanic series, as they occur on the margin of the limestone at Well Farm, and three quarters of a mile farther west.

The slates on the west side of Stoke Gabriel seem to be brought up by a fault. They are overlain by a large patch of slaty limestone, which seems to rest on purple volcanic rocks near Duncannon, and by a circular outlier of blue and buff weathered limestone farther north. Near its western termination the slate is faulted against limestone, of which the small patch near Ham Barn might be a faulted continuation.

There are numerous faults between Stoke Gabriel and Longcombe affecting the relations of the limestones and volcanic rocks, and the surface evidence is often unreliable.

* Champernowne obtained the original specimen of *Cyathophyllum? bilaterale* described in *Quart. Journ. Geol. Soc.* vol. xl. p. 503. pl. xxiii. from a quarry "on the south bank of Tuckenhay Creek." No doubt this quarry was meant.

The limestones and schalsteins of Aish are cut off by a nearly north and south fault against the great mass of limestone north of Stoke Gabriel. On the west side of this fault there is a small patch of very coralline limestone, near a place called Hoil (on the 6 inch map), in which *Spongophyllum Sedgwicki*, identified by Professor Frech, is conspicuous. This limestone, as well as that of Aish, where unfaulted, is probably under the volcanic rocks. The limestones of Aish are exposed in a quarry south-west of Aish House to a depth of 20 feet; at Aish they seem to be horizontal.

The limestones at, and south of, Longcombe occur between two faults which unite on the west side of Aish. The westernmost of these faults passes "Parliament House," the little house in which William of Orange held his first Council. The larger patch of limestone seems to pass under volcanic rocks on the south and to be bounded by a fault on the east, which coalesces with the main dislocations and cuts off the small patch of limestone on the west of Longcombe. The limestone patch faulted against Lower Devonian, south of Longcombe, seems to rest directly on Eifelian slates, and to be lower in the series than the other patches. South of Parliament House a band of limestone is cut off on the east by the fault. At its western extremity this limestone is exposed; the beds dip south and west, and are overlain by shaly yellowish-grey and purple volcanic materials much contorted. The persistence of this band is doubtful. The Lomentor limestone seems to be faulted on all sides, or overthrust on Eifelian, or Lower Devonian strata.

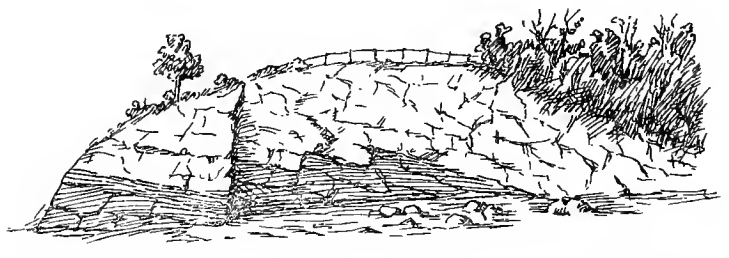
At Aish the volcanic rocks seem to overlie the limestone, and although their persistence to Higher Yalberton on the east is not ascertainable, owing to extensive washes of Lower Devonian *débris*, a connection between the Ashprington and the Crabs Park volcanic products is very likely to have taken place in this direction. The faulted limestone patches north of Longcombe are associated with red rocks, so imperfectly evidenced that I cannot say whether they are volcanic or Lower Devonian. If volcanic, the limestones, which are displaced portions of the same horizon, would be separated by them from underlying Eifelian slates. If Lower Devonian, their positions would have to be explained by thrust and step faults.

From Longcombe westward the volcanic rocks are bounded by slates, in faulted or unfaulted contact except—near Weston House; between Bridgetown and True Street; and at Totnes Cemetery—where limestones are met with. South of Berry Pomeroy, east of Weston House, a good sized mass of limestone, bounded on three sides by the volcanic series, yielded *Alveolites vermicularis, Favosites Goldfussi* and the following, identified by Herr Frech, *Heliolites porosus, Mesophyllum damnoniense, Syringopora crispa*. There are two patches of limestone, probably connected with this, on the opposite side of the stream. The relations of the limestone are probably affected by a fault prolonged in a south-easterly direction from True Street. Between True Street, Great Court, Bridgetown and Bourton the

boundaries of the volcanic rocks, where in contact with slates, are invariably faults running east and west, and shifted by dislocations trending north by west and south by east; the only exception being a somewhat doubtful north-east and south-west fault between True Street and Bourton. South of True Street limestone dips under the volcanic rocks, but its extension is very doubtful, through lack of evidence between Highlands and True Street. Thin bedded limestones, associated with slates apparently dipping under volcanic rocks on the south, are visible at a quarter of a mile east of Bourton.

Similar limestones are imperfectly evidenced in an orchard south of Bourton. The volcanic rocks rest on limestone. At Redhill quarry by the Dart, Champernowne, in unpublished notes, thus describes the section—"Here the mass, which is scoriaceous at the base, rests on an eroded step-like surface of limestone beds dripping south-east." Godwin-Austen ascribed this step-like junction to faults, but Champernowne regarded it as "a case of contemporaneous erosion involving a disturbance of the reefs by the volcanic forces."

FIG. 11.—REDHILL QUARRY, NEAR TOTNES.



Greenish, buff brown weathered, decomposed igneous rock, resting on limestone, which dips at 15° to 20°.

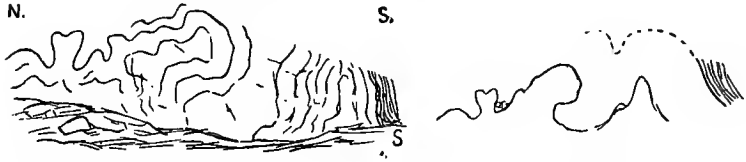
To the south of this the limestone is again visible, underlying the volcanic rocks without any appearance of irregularity. Still farther south irregular buff and grey slates, with limestone lenticles containing *Cystiphyllum vesiculosum*, are exposed by the high road below the limestone. The limestone in the wood contains an isolated mass of igneous rock to the east of which it extends for some chains, probably faulted against the volcanic rocks on the north but passing under them on the south. In this extension the limestone is exposed in a quarry near Dartan Moor where it is partly massive, partly broken and slaty, and excessively contorted, as shown in the sketch (Fig. 12).

East of Dartan Moor limestone is exposed in an old quarry at Endsleigh, where buff schalsteins, so blended with limestone as to resemble a schalstein-kalk, rest on massive dark grey limestones, veined with calc-spar and with a lenticular peroxidated slaty seam. A coral obtained here was described by the late Professor Nicholson as "a *Caunopora* belonging to a common but

undescribed Stromatoporoid of Devonshire. It is probably referable to the genus *Hermatostroma*."

The continuation of the Endsleigh limestone eastward is broken by two parallel faults, eight chains apart, by which it is shifted northward and forms a mass apparently in an inverted anticline in the volcanic rocks on the slope south-east of Bourton. The easternmost fault cuts off a mass of coralline limestone, of grey and deep red colours, on the west, near Highlands. Amongst the corals *Cystiphyllum vesiculosum* was obtained from this limestone. Nicholson identified *Alveolites suborbicularis*, *Clathrodictyum*, probably a new species, and Dr. Frech recognised *Favosites reticulatus* and *Mesophyllum damnoniense*. Farther south the fault cuts off a patch of thin-bedded limestone, resting in an inverted syncline on Eifelian slates, against volcanic rocks on the east. It may, therefore, be inferred that these isolated limestone patches formed a continuous mass, resting on the Eifelian slates and overlain by the volcanic materials. There is no reliable evidence for connecting these volcanic rocks with the main mass; they appear to be cut off by an east and west fault at Great Court, and may rest on limestone at a spring, west of that place.

FIG. 12.—QUARRY NEAR DARTAN MOOR.



Massive limestone and broken limestone Schalsteins. General structure.

At Higher Weston farm, and in an orchard south of it, wells have been sunk just below the feature made by the volcanic rocks. One of these wells is said to be 160 feet deep. No volcanic materials were turned out, the strata penetrated being, apparently, dark grey slates, overlain near the surface by dark shaly limestone and buff fossiliferous (decomposed limestone) shaly beds. The limestone and buff shaly fragments, turned out, recall the Hope's Nose Eifelian limestones and contain numerous Brachiopods and corals. The Spirifers were pronounced by Professor Kayser to be *Spirifera aff.* (but not the true) *speciosa*, Schloth. Professor Frech identified the following:—

Atrypa reticularis, *Linn.*
Actinostroma verrucosum, *Goldf.*
Cyathophyllum cæspitosum, *Goldf.*
C. dianthus *Goldf.*
C. vermiculare, *Münst* (præcursor *Frech*).
Mesophyllum damnoniense, *M. E. and H.*
Favosites Goldfussi, *M. E. and H.*

Beds of dark grey limestone, containing similar Spirifers to those at the wells, are exposed at the border of the volcanic series in a narrow brook channel to the south of Lower Weston Farm.

At Rose Cottages, south of Totnes, there are lenticles of limestone in the buff slates on the volcanic boundary. There is a small patch of limestone between the volcanic rocks and the Eifelian slates, crossing the Great Western Railway at Totnes Cemetery. Near Longcause, lenticles of limestone occur in the slates near the volcanic boundary. In the high road at Redworth two small patches of highly altered limestone are visible in or under the volcanic rocks, which here appear to be faulted against Eifelian slates on the north and east.

Atrypa reticularis occurs in buff slates at their junction with the volcanic, just outside the map near Follaton House.

The well sunk by Isler and Co. at the Lion Brewery, High Street, Totnes, indicates the presence of shaly Eifelian limestones probably forming a syncline beneath the volcanic outlier of Totnes Castle. Beyond the Castle mound there are no exposures in the space indicated as volcanic on the map, and part of the made ground may be volcanic rock disturbed. The section thus interpreted is:—

	Ft.	in.	
Made ground and soil	21	0	Probably in part volcanic
Shaly rock -	3	0	Eifelian limestone.
Blue limestone rock	2	6	
Blue slate rock	139	6	Eifelian slates.

Taken in connection with Weston wells, and the entire absence of evidences of volcanic intercalation in the Eifelian slates, it seems evident that the earliest eruptions of the Ashprington series took place during the later, or latest, stages of the deposition of the Eifelian slates. From the disposition of the volcanic materials indiscriminately on these slates, and on successive stages in the limestone formation which ensued, it seems clear that the earlier eruptions were so localized as to permit of these organic growths taking place and being overwhelmed at different stages by subsequent eruptions. On the margin of the eruptive foci, under favourable conditions, coralline growths would spread over the volcanic materials, as at Sharkham Point, and, perhaps, near Aish, etc., where subsequent disturbances may have entirely effaced the original relations of the rocks.

Dartington, Marldon, and Ipplepen District.

In the introductory notes the general character of this area has been roughly sketched. The New Red rocks west of Torquay conceal a tract between the Torquay and Paignton anticlines, in which the disturbances of the Middle Devonian rocks must have been considerable. As faults cannot be traced in the slate areas away from the limestones, and the dislocations affecting the latter were only shown where obvious, through displacement or shifting of the boundaries, it is not possible to say how far the structure may be influenced by faults which have not been detected, and consequently to distinguish slates which may have replaced limestones from the Eifelian slates which underlie

them. North of Staverton the limestones are so feebly represented and so closely associated with the slates, that they appear rather to be impersistent and irregular developments in them than faulted remnants of a persistent horizon.

Looked at in a broad way, we may regard the slates on the south of the Dartington and Marldon limestones (the Berry Park slates of Champernowne) as Eifelian, or the lowest beds of the Middle Devonian. Above these come the bedded limestones, which include the Berry Pomeroy outliers, and extend from Marldon to Dartington, and thence to Fishacre. The Ipplepen limestone mass is either altogether above the Dartington limestones, or represents them in its lower beds south of Orley Common. In either case the Dartington limestone passes out into slates in the Broadhempston country, but it may be continued eastward in the Newhouse Barton, Yarneford Copse, Wrigwell House, Bulleigh Barton, and Whilborough limestones. The limestone bounded on the south by volcanic rocks on Blair Hill, north of Bulleigh Barton, is an upper limestone mass, in the same category with that of Ipplepen, the schalsteins being a development in the slates with occasional dark limestone bands and tuffs, which overlie, or replace, the Dartington limestones.

The replacement of the limestones by slates with contemporaneous volcanic rocks is conclusively proved (as already remarked) in the area on the west, in Sheet 349. The slates with tuffs in the area under description have been regarded as the commencement of this replacement. These would be above the Dartington limestone on the assumption entertained by Champernowne that the Dartington structure is a syncline, the limestone separating older from newer slates. If we assume the contrary hypothesis, the Marldon and Dartington limestones would be partially replaced or occur as outliers, and the volcanic materials would be associated with the uppermost beds of the Eifelian slates, or with slates representing the lower (locally even the higher) parts of the Eifelian limestone.

The volcanic rocks of this area are brought into relation with those of the Ashprington and Goodrington districts by Champernowne. Referring to a coarse tuff faulted against dolomitic limestone at Aish, north of Stoke Gabriel, he wrote:—* "This tuff consists chiefly of red slaty-looking patches, decomposed felspar crystals, and grains of quartz. A precisely similar rock resting on limestone occurs near Watton [Waddeton] village, and beds of like constitution, but not red, are interstratified with bluish slaty shales over the Dartington limestone, being well exposed in the Ashburton railway-cutting, also overlying the limestone of Bulleigh Barton, and south of the limestone of Clennon Hill near Goodrington. . . . These belong to a characteristic type . . . they are never amygdaloidal, and cannot have flowed, but seem to correspond to the Nassau

* On the Ashprington Volcanic Series, *Quart. Journ. Geol. Soc.*, Vol. xlv., p. 369, etc.

'porphyritic schalstein' so-called." In his unpublished notes the following passage occurs:—"In the broken and troughed country of Dartington and Little Hempston, the lavas appear to be absent, ash beds, both fine-grained and flaky, as well as coarser brecciated layers, alone representing this group. Blue-black slates intervene between them and the great limestone below, so full of Middle Devonian fossils. With the slaty beds above the ash, etc., many blue limestone layers are interstratified, apparently unfossiliferous. Dartington Hall and Little Hempston Parsonage are built on the latter, which are finely exposed in the railway cutting on the left bank of the Dart."

In allusion to the difficulty he experienced in distinguishing the slates above mentioned from those below the limestone, the paper on the Ashprington series concludes with the following sentences:—"But why should there not also be slates neither exactly above nor below the limestone, but replacing it? So that De la Beche's words would be true, viz., that the geological continuation of certain limestone appears to consist of slate." Dartington Parish Church is built on slates bounded by the Dartington limestone (along a north and south fault?) on the east, and by a mass of decomposed igneous rocks at Knoddy and Yarner on the west. The rock (No. 1084) of Yarner Beacon is a dolerite. These igneous rocks rest on the slates, but shaly limestone is exposed beneath them in an old quarry at Lownard, near Yarner.

Farther west, in Sheet 349, there is not the slightest evidence of the continuation of the Dartington limestone, so that we must conclude that its place has been taken by slates with schalstein; and that the isolated Eifelian limestone of Peloe (Paytoe on the old map) in which Champernowne obtained *Calceola*, and the limestones of Buckfastleigh, on the north and of Hazard, on the south, were not connected with it. North of Staverton and west of the Ipplepen mass there is not sufficient evidence to connect the various occurrences of limestone.

The strikes of the area vary between east and west, and north and south; this is partly due to the dying out of the Lower Devonian anticlines, partly to the prolongation southward of nearly north and south strikes from Newton Abbot. The consequence of these strike variations is to repeat the rocks indefinitely, and rather to discount the idea of the occurrence of any great structural curves. There are numerous examples of slaty limestones passing into slate, but these are seldom sufficiently distinctive in character, or fossil contents, to justify their correlation with the Eifelian limestone with any degree of certainty.

Eifelian slates seem to pass under the Dartington limestones on the south. They contain limestone lenticles near the junction on the south-east side of Dartington Park and have the appearance of passing into the limestone. *Aulopora* and other fossils occur in them south of the Vineyard, and *Fenestella*, north of Dartington Hill Copse. Near Hampstead a lenticular patch of limestone associated with slate occurs in the Eifelian slates; and

on their southern border the Little Hempston limestones are slaty near Grattons. On the east of Little Hempston Wood *Phacops batracheus* (= *P. granulatus*) was found. The slates of Gatcombe Park are fossiliferous. These slates are regarded as Eifelian and below the faulted limestones on either side. Near Shadrack Cross they contain *Aulopora, Zaphrentis, Phacops, Spirifera;* and east of Shadrack, *Phacops* and *Spirifera speciosa.* At Netherton *Atrypa reticularis* was found in them. Between the limestone near Uphempston and the adjacent patch of New Park Hill plantation there is an interval occupied by slate; north of Shadrack Cross there is no representative of the limestone between these slates which do not contain tuffs and those of Penball Cross which do. If, therefore, these phenomena are not due to faults, which can only be inferred theoretically, it is impossible to separate the slates with tuffs from the Eifelian slates.

The Battleford Copse limestone is considered to belong to the same series as the limestones of New House and Yarneford Copse, and the slates from Red Post eastward, which are frequently red stained, may, or may not, be Eifelian. East of Weekaborough Oak Cross, grey fossiliferous slates contain *Spirifera speciosa, Atrypa reticularis, Streptorhynchus* and *Phacops.* At Aptor Barn the slates are red, they contain many distorted fossils, fragments of trilobites, *Streptorhynchus umbraculum, Spirifera,* etc.

In the lilac-red slates north of Westerland House *Spirifera speciosa, Cyathocrinus nodulosus, Pleurodictyum* and *Zaphrentis* were obtained.

Grey fossiliferous slates of the Berry Park type, exposed in a quarry west of Westerland House, yielded *Leptæna interstrialis, Spirifera speciosa, Streptorhynchus* and *Strophomena rhomboidalis.* To the north of this, by the lane to Culvertor Copse, the slates contain *Orthoceras* and a small gasteropod (*Pleurotomaria,* identified by Kayser). From Culvertor Copse to Totnes the prevalent types of Eifelian vary, from the irregular Berry Park type to that of Ellacombe and Mudstone Bay—fossils are of common occurrence, as decomposed and distorted casts or impressions. *Atrypa reticularis* was recognised in Blackpool Clump, near Berry Castle Lodge, and near Springville, north of Totnes.

Berry Pomeroy, Marldon and Dartington Limestones.

The limestones of this group are so seldom seen in unfaulted junction with the slates that the recognition of the shaly Eifelian passage limestones and slates at their base is naturally exceptional. They represent the bedded limestones of Daddy Hole, and although, where unfaulted, their lower beds would correspond to the Eifelian limestone, it it not possible to say how far they may be regarded as included in that series.

Near Springville House, north of Totnes, there are three contiguous patches of Eifelian limestone, possibly connected, but of this there was not sufficient evidence. The westernmost

patches consist of dark grey limestone veined with calc-spar, under thin irregularly bedded limestone, overlain (invertedly?) by papery shale; and of dark grey limestone associated with buff argillaceous material, very similar to the Hope's Nose limestones.

The larger mass, on the east, is composed of dark grey limestones, more or less slaty. These are well exposed in Mockwood Quarry where they exhibit a complex series of zigzag plications. This limestone is probably terminated by fault on the east. In a specimen labelled Mockwood Quarry, of pale grey compact limestone, Professor Frech identified *Cyathophyllum tinocystis*, Frech—an Iberger Kalk species. The character of the specimen suggests higher beds thrust or folded in.

The limestones south of Gatcombe Park are connected by a narrow, probably faulted, isthmus, On the south of this there are signs of limestone and schalstein bands in the slates. The larger mass is frequently slaty, and in one place (shown on the map) it may surround a plicated mass of slates. Contortions in the limestone are well shown in a quarry overlooking Gatcombe Park. Dark bluish-grey limestones associated with buff earthy matter (as at Hope's Nose) are exposed south-west of Combepark Cross. East of Little Hempston Wood the limestone is coralline and contains *Alveolites suborbicularis* and *Mesophyllum damnoniense* identified by Professor Frech. The faulted patches, near Netherton, point to the connection of these limestones with those of Berry Pomeroy on the south, and through them, with the limestones on the north border of the Ashprington series. In one of these patches, at Sandlane Copse south of Netherton, the limestone is cleaved, as in the Hope's Nose coast.

The surface evidence between the Berry Pomeroy limestone patches is, in many cases, so indefinite that it is impossible to say that they may not be connected by—and based on—slates with limestone bands or lenticles, representing the lower part of the Eifelian limestone. The most southerly mass, on the north of the Ashprington series, is exposed in a quarry in Southfield Wood showing pale-grey limestone, yellow-banded in places, weathering dark grey.

At Berry Castle Lodge, a triangular patch of contorted bluish-grey calc-veined limestone is exposed; it appears to be faulted on all sides. Near the end of the wood, on the west of Berry Castle Lodge, a small patch of limestone was also detected; relations not shown. These limestones were no doubt once connected with the faulted patches near Longcombe on the south, and the Afton and Marldon limestones on the north. The slates of Shadrack Cross lie between two nearly north and south faults. The westermost cuts off the Uphempston limestone. The eastermost cuts off the limestone south of Netherton, and forms the western boundary of a long patch of limestone with easterly dips in New Ground Copse. This mass may be connected with that on the east in which *Alveolites suborbicularis* was obtained in Park Corner Copse.

The third and largest mass occupies the high ground between Afton and Northtor Cottages. It is bounded on the south by a fault along the north-western walls of Berry Pomeroy Castle. There is every reason to conclude that the Afton limestone rests on the slates which separate it from the limestones of Aftontor Quarry on the north. From Aftontor Quarry the limestones extend to Marldon, their sinuous boundaries on the north, between Aftontor Wood and Butterball Copse, denoting a natural, but, no doubt, frequently inverted junction with the slates of Aptor and Weekaborough Oak Cross. On the south the boundary is a fault at Loventor. This is shifted by a cross fault at Afton, and forms the southern boundary of the Afton limestone at Berry Pomeroy Castle, already mentioned. Near its northern margin the limestone, east of Butterball Copse and south of Aptor, contains numerous corals including *Amplexus tortuosus* and *Cystiphyllum vesiculosum*, and the following identified by Professor Frech, "*Cyathophyllum cæspitosum*, Goldf. *Mesophyllum cylindricum*, Schlüt. *Cœnites* n. sp. (not occuring in Germany)."

At Burrowbottom Barn, south-west of Aptor, there are two small outliers of coralline limestone in which *Cyathophyllum cæspitosum* "immersed in a colony of *Alveolites*" (identified by Nicholson), *Cyathophyllum helianthoides* and *Cystiphyllum* were obtained.

At Hazelwood, where thin-bedded limestones have been quarried, the continuity of the limestone is broken and shifted by faults.

Near Strainytor Copse numerous inverted contortions with easterly dips are shown in an old quarry. At Higher Westerland Quarries bluish-grey limestones, mostly crinoidal and containing corals in places, are exposed. In one of the quarries, a sharply inverted syncline is shown. *Alveolites vermicularis*, *Aulopora*, *Favosites* and *Spirifers* are obtainable. At Marldon the limestones are bounded by faults; they exhibit various changes in strike. "*Alveolites suborbicularis*, Lam., associated with stems of a species of *Pachypora*," and a "rugose coral, partly immersed in a Stromatoporoid" were recognised by Professor Nicholson.

North of Marldon a fault-bounded inlier of distinctly bedded, partly crinoidal, limestone is exposed in the valley south of Compton, in the New Red area. It contains *Alveolites vermicularis*, *Heliolites porosus*, *Spirifera* sp., and "*Stromatopora Hüpschii*," Barg. (with "*Caunopora* tubes") which was identified by Nicholson.

A small limestone inlier occurs to the east of this; and further east is the Stantor Quarry inlier. In this quarry the even, mostly thin-bedded, limestones are excessively contorted. Numerous sections of Gasteropods are shown in some of the beds. *Stromatopora Bücheliensis*, Barg. was obtained here and identified by Professor Nicholson.

The Marldon limestones in their extension to Aptor seem to rest on red slates on the south. South of Marldon Tor Plantation there is no reliable surface evidence.

At Aptor Brake the limestone is shifted northward by faults. At Aptor the rock is coralline in places; one bed full of *Favosites*, etc., was noticed; the bedding is generally even. Between the Aptor limestone mass and that of Herhill Copse, grey slates are in faulted junction with the New Red. The Herhill Copse limestone is faulted against these slates on the east, but the shaly limestones on its southern border are indicative of a natural junction. Limestone is imperfectly exposed on the New Red boundary in a valley south of Higher Weekaborough, but beyond this there are no indications of limestone along the New Red boundary until Battleford Copse is reached. Between Battleford Copse and Red Post there seems to be a small patch of limestone associated with red slate.

From Uphempston the limestones in direct continuation with those of Dartington Park begin. The Uphempston limestone is faulted against slates on the east, west, and south. Near its southern boundary the dips are westerly, and the rock is partly dolomitic. On its northern border even-bedded, dark bluish-grey, white-weathered, hackly fractured limestones, locally full of corals, seem to rest on bluish-grey slates. Amongst the corals Nicholson recognised *Alveolites subæqualis*, Ed. and H., and a *Cyathophyllum*, (perhaps *C. ceratites*). Mr. Whidborne identified *Phillipsastræa* (*Smithia*) *Hennahi*. Between the western fault boundary of the Uphempston limestone and that of New Park Hill Plantation there is an interval of twenty yards, or so, of slate with some signs of tuff. Unless the slates with tuffs on the north are newer than the slates without tuffs on the south of it, the New Park Hill Plantation limestone (which is partly dolomitic) occupies an inverted syncline; if not, the interval between it and the Uphempston limestone must be bridged by a fault.

South of Little Hempston Church a nearly east and west fault cuts off the limestone on the north against dark slates. Both series are extremely contorted. The fault cuts off a small contorted patch of limestone at the north end of Little Hempston Quarry, and to the east the dark slates are well exposed in the road cutting descending the hill toward Little Hempston Bridge. On the north of the fault we encounter limestones in the dark slates (or shales) in four places. One of the limestone beds is cleaved and inverted, and in one spot nipped out. Further on, dark, partly calcareous slates, in places passing into limestone, are to be seen. A little lower down, dark grey tuffs with a southerly dip are exposed in the slates. These beds, although faulted against the limestone on the south, are in direct relation to it on the east. The problem to be solved is how far the phenomena may be due to an actual outward passage of the limestones into slates with occasional limestone bands, in an area of local vulcanicity, and to what extent local vulcanicity irregularly interrupted the upward growth of the limestone.

Near Parkhill, Little Hempston, the limestone is interstratified with dark blue and grey slates, and apparently overlain by dark slates, calcareous in places. In the wood east of Grattons, dark

grey slates are intercalated with the limestone. On the summit between Grattons and the Dart the limestones enclose an irregular tract of slates bounded by fault on the north, and presumably an anticline of Eifelian slates. At Grattons, and near its southern boundary (which may be faulted), the limestone is slaty. Dolomitic limestone is encountered in the north part of the mass, west of Little Hempston, and on the west and south of the central slate patch.

The alluvium of the Dart and river terraces bordering it, in Dartington Park, conceal the connection of the Little Hempston and Dartington limestones. South and south-east of Dartington House, the boundaries of the limestone are very indefinite, owing to the plication of bedded or flaggy limestones which pass, by irregular intercalation, into slates.

In the old quarries on the south of the river terrace (north of Dartington Hill Copse) rather thin-bedded dark bluish-grey limestones are exposed, apparently resting on shaly limestones, on Eifelian slates of the Berry Park type, and dipping east 15° south, at 18°. Traced northward, these limestones are found to pass into slates by intercalation on the east and west, and are cut off by the Little Hempston fault prolonged, east of Dartington House. Grey slates with limestone lenticles are exposed by the Dart at the Boat House. The Dart seems to run along the strike of an inverted anticline of slates and slates with shaly limestones, separating the Little Hempston limestone from the limestones in Dartington Park which belong to the same series.

On the south of Dartington Gardens flaggy limestones are exposed in a quarry, giving a south-easterly dip of 40°. In a copse on the summit, some chains south-west of this, the bedding is nearly horizontal. The connection of this limestone with the main mass in Nellie's Wood cannot be proved, and its relation to the limestones on the east is obscured by faults Between Nellie's Wood and Dartington Hill Copse, surface fragments suggest the presence of volcanic materials in the Eifelian slates, and there are signs of lenticular bands or lenticles of limestone in the slates on the east and south of Nellie's Wood. West of Nellie's Wood, a quarry in Symon's Tree Wood exhibits limestone, partly shaly and associated with reddish slate. The limestones appear to be shifted by fault on the south of Foxhole Copse, but toward Shinner's Bridge they are well exposed in the stream gorge. The road between Parsonage Cross and Dartington House exhibits even-bedded limestones, dipping at low angles northward, in the quarry near its western margin, and westward at Symon's Tree Barn. Unless indicative of strong zigzag plication, or near a faulted western boundary, these low dips denote a less thickness of limestone here than in the Shinner's gorge.

At six chains north of Symon's Tree Barn there are indications of slate with volcanic bands in the limestone; these terminate in a small mass of diabase, at 13 chains northward. The limestone on the west of the diabase is dolomitic. Just north of

this, in Chacegrove Wood, there is a larger mass of diabase, apparently faulted on the south (perhaps by the westerly prolongation of the Little Hempston fault). Limestones seem to dip off the diabase on the east and north, but on the west there are only indications of the presence of irregular beds of dark limestone associated with slates. In fact, the continuity of the Dartington limestone round Chacegrove Wood is most uncertain. This cannot be properly shown on the one-inch map, on which a line has been drawn as the north border of a tract where slates and tuffs, etc., may take the place of the limestones. This indefinite tract terminates in a bold feature in Staverton Ford Plantation, made by a mass of diabase flanked by limestone on the north and west slopes, and also on the east and south-east. In one place there is a trace of schalstein interbedded in the limestone. In Park Copse the continuity of the limestone is nearly, or altogether, broken by a great mass of diabase which continues on the north side of the Dart to Reevacre Cross, bounded on the east by a continuation of the Dartington limestones from Thistlepark Plantation. On the west side of Park Copse there is not sufficient evidence to prove whether the diabase is bounded by limestone or by slates. A specimen of the rock from Park Copse Quarry (No. 1079) is an ophitic dolerite.

Champernowne * described the limestone in Pit Park Quarry, Dartington, as a light grey, highly crystalline rock. A small part friable and almost sandy. From this quarry he obtained *Alveolites, Favosites cervicornis*, var. *reticulata, Heliolites porosus, Cystiphyllum vesiculosum, Heliophyllum*, simple *Cyathophylla*, Crinoid joints, pelvic plates of *Hexacrinus* (rare), and occasional brachiopods among which Davidson recognised *Spiriferina cristata*, var. *octoplicata*. From a quarry in an adjoining field a specimen of *Uncites gryphus*, in the Jermyn Street Museum, was obtained.

About 30 chains north of Dartington House *Cyathophyllum cæspitosum* and *Smithia Hennahi*, Ed. and H., identified by Nicholson, were found in the limestone. Nicholson gave Dartington as the locality for *Actinostroma clathratum*, Nich. From its specific name, *Parallelopora dartingtonensis* was no doubt obtained here. The *Stromatopora* obtained by Champernowne in Pit Park Quarry were not specified.

East of Thistledown Plantation a broad river terrace conceals the continuation of the limestone, which is visible on its margin, by the alluvium, for a distance of 10 chains south from the underlying diabase. For 30 chains further south, slates are present. *Atrypa reticularis* was found in them on the west of the river terrace. A band of tuff is here shown on the map; it completes the elliptical strike over the interval where the limestones are absent.

Just north of the timber yard in Park Lane, Dartington House, a well was sunk to a depth of 30 feet in dark grey

* *Quart. Journ. Geol. Soc.* vol. xxxv., pp. 67-68, 1879.

slates, calcareous in the lower part. Between the timber yard and the outbuildings, behind Dartington House, limestone is exposed, but no evidence of its persistence, along the north-east and south-west direction of its strike, was procurable.

Felspathic tuffs are visible in the slates on the high ground north of Dartington House, in the band on the east of the House, above mentioned, and in the grounds south-west of the House.

The slates of Staverton contain a few beds of slaty limestone in the Ashburton Branch Line section, near their junction with the prolongation of the Park Copse diabase mass in Staverton wood. Beginning with these slaty limestones, the following beds are exposed in the railway. between the slates of Staverton and the Little Hempston limestone :—

1. Buff and grey slates, with a few beds of slaty limestone, junction with diabase not exposed.
2. Diabase for a distance of twenty chains.
3^1 and 3^2. Intercalated slates and limestones overlain by limestone, with occasional slaty partings, and bluish-grey distinctly-bedded partly crinoidal limestone, also exposed in a quarry in the wood above the Line. The limestone beds vary from two or three inches to two or three feet in thickness. *Favosites* and *Cystiphyllum* were noticed in the cutting. These beds form the cutting for 17 chains; they are the continuation of the Dartington limestones from Thistlepark Plantation.
4. Dark grey partly calcareous slates, similar to those turned out of the well on the north of Dartington House, exposed for four chains.
5. A hard grey felspathic tuff bed, well exposed in a quarry above the Line, overlies the dark slates, and is succeeded by slates with irregular bands of tuff here and there, which form the cutting for four chains and pass under.
6. Slates with beds of limestone, about a chain in breadth ; and either overlain by, or faulted against, 7.
7. Slates for about 10 chains, dipping eastward under :—
8. Bluish grey limestones with intercalcations and partings of slate. This band may be No. 6 shifted by fault or fold; it cannot be traced further north than a point (south of Parsonage Farm) on the slope above the appearance of 6 at the base of the cutting.
9. Slates with bands of tuff separating the limestone horizon (8) from slates with limestone beds which form the border of the Little Hempston limestone.

Following the rocks along their northerly or north-north-easterly strike from the cutting, we find that the diabase (No. 2) and overlying limestone (3) attenuate and disappear at Reevacre Cross, whilst the overlying beds, Nos. 4 and 5, increase in breadth from eight chains in the cutting to twenty-two chains at Buckyett, tuffs being irregularly developed in them in a continuous mass, directly above the limestone (3), and in irregular patches near Buckyett. South of Buckyett the slates and tuffs are bounded by hard bluish limestone beds (with a south-easterly dip of 40°, in a quarry near Parsonage Lane). Similar limestones associated with slates are exposed north of Buckyett, and dip off the slates and tuffs in an easterly direction. The same calcareous band has been continued, on the evidence of an exposure, north of Longford Bridge, and of pits and slight indications, round the coarse and fine tuffs of Ford Cross as far as Fishacre Cross. Whether in a persistent limestone zone or

not, these limestone occurrences are evidently on the same stratigraphical horizon, and they appear to be the northerly continuation of No. 6, and perhaps No. 8, the limestone horizons in the cutting. The attenuation of limestone No. 3 (continuation of the Dartington limestone mass), which is associated with slates near Reeveacre Cross, makes its correlation with the Buckyett calcareous band probable, and both are no doubt cut off by the east-north-east and west-south-west fault which throws the tuffs of Ford Cross against the limestone of Fishacre.

To return to the cutting, the slates and tuffs No. 9 have a breadth of only five chains, but tracing them along the border of the Little Hempston limestone, they are found to fill the increasing space between that limestone, which strikes in an easterly direction, and limestone No. 8 in the cutting which strikes northward; and continuing to Bycellar Bridge (on the 6-inch scale map) they exhibit patches of tuff here and there, and also coarse tuffs or volcanic breccia in places. These slates and tuffs are separated by blue-grey slates from the series near Buckyett. It seems certain that the tuff-bearing slates Nos. 5 and 9 are repetitions of the same series. Whether the calcareous horizons 6 and 8 are the same or not, there can be little doubt that they severally belong to the Dartington and Little Hempston masses in an area where showers of tuff and muddy sedimentation rendered continuous coralline growth impossible, or very partial.

In the railway cutting at Bycellar Bridge blackish contorted slates, with irregular beds of dark calc-veined limestone, are overlain by slates, or shales, with tuff in places; appearances of irregularity in the junction are probably due to the intersection of sharp plications along their strike. The calcareous beds cannot be traced southward by surface evidence, but an exposure in the railway cutting north of Little Hempston Bridge connects them with the dark slates and limestones exposed in the road section leading to Little Hempston Bridge (on the north side of the Little Hempston fault), which have already been referred to.

In the railway cutting, north of Little Hempston Bridge, dark slates are shown with beds of dark blue limestone, which are much contorted and seemingly impersistent. Near this tuffs are visible in the slates.

The road cutting in Penny's Wood opposite Bycellar Bridge, proceeding southward, shows successively:—

Pale greenish slates, or shales, for a few feet.
Lilac or Indian red slates, or shales.
Grey and greenish slates, or shales.
Even shales with beds and lenticles of limestone.

This calcareous horizon, of which limestones occupy but a small part, is from 15 to 20 feet thick. It cannot be traced far on its strike. It is bounded by irregular grey clay-slates in which, toward Red Post, traces of tuff are found.

East of Penball Cross masses of coarse tuff inosculate with thick slates, or mudstones, containing *Zaphrentis*, badly preserved

brachiopods, etc. Between Bittam's Barn and Penball Cross there is an exposure of limestone associated with slate. This might be a continuation of the calcareous horizon in Penny's Wood shifted by fault. It cannot be traced north of Bittam's Barn.

North of a line drawn from Tallyho Bridge eastward to Red Post grey slates, apparently without limestone bands or traces of volcanic rock, occur between the Battleford Copse limestone and the tuffs and limestones of Fishacre.

Between Bittam's Barn and Penny's Wood red and green slates are visible. At Ford Bridge slates of an indian red tint occur. Between Bittam's Barn and Battleford Copse lilac tints are noticeable, in places, in the slates. In the road from Ford Bridge to Reevacre Cross grey slates, with a cleavage dip of 42° south-east, are shown to dip at 40° north-east by brown fossiliferous bands, in which small impressions of a shell (not unlike *Cardium palmatum*, but with no signs of ornamentation) were noticed.

Near its termination, the Dartington limestone is exposed to a depth of from 15 to 20 feet in quarries south of Reevacre Cross; the rock is partly red, and rests upon a few feet of red and buff tuffs which separate it from the hard diabase below. This is important, because there is not sufficient evidence in Dartington Park to prove whether the diabase is intrusive or contemporaneous, or partly intrusive partly effusive, and the presence of the tuff on it tends so show that the larger mass was probably a lava.

The slaty margins of the limestones and the obviously close relationship of the dark slates with limestone bands with the Dartington and Little Hempston limestones—whether they denote an upward, downward, or horizontal passage into them, and whether the tuff bearing slates are above or below the dark slates with limestone bands—certainly prove that the limestones in this area are largely replaced by slates, and that this was partly due to showers of tuff rendering the waters unfit for the extension of the coralline growth.

No distinction can be drawn between Eifelian slates and slates, etc., replacing limestones, in the district north and north-east of Staverton and between Battleford Copse and Fishacre Bridge.

At Fishacre dark grey thin-bedded limestones, partly shaly and with a local tendency to pass into slates, or shales, are faulted against tuff-bearing slates. These limestones can be traced for forty-five chains west from Fishacre. Their continuation with an adjacent band of similar dark limestone, on the north of Ringswell Cross, is very probable. The last-mentioned band is exposed in three quarries, in which the dark-blue calc-veined limestones occur in the slates, but cannot be traced to the Ambrook.

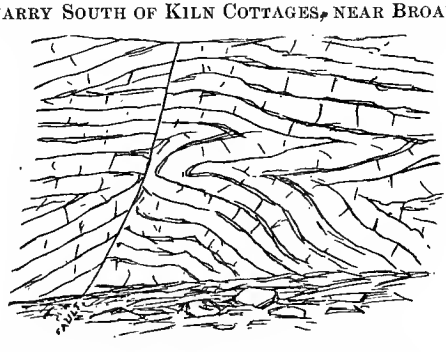
At Great Ambrook the slates contain traces of crinoids and *Fenestella;* west of Little Ambrook *Atrypa* and other brachiopods, very badly preserved, are to be found in them.

A little dark limestone is exposed in the slates on the south of the eastern termination of the band. North of its western termination there are some slight evidences of the continuation of the Fishacre limestones by slates with occasional beds and lenticles of limestone in a northerly direction to Broadhempston. These are indicated and greatly exaggerated by the band on the map.

At Bow Mill the slates are partly knubbly and calcareous. Blue slates, partly calcareous, have been turned out of a well south-west of Broadhempston Vicarage. Limestone lenticles occur in the slates in the west part of Broadhempston and at Sneydhurst, near the Vicarage. Thin bands of limestone were observed in the slates, near the sharp bend in the road to Torbryan, south-east of Broadhempston. The Broadhempston limestone is no doubt a development of these calcareous manifestations, so that its boundaries cannot be regarded as of much stratigraphical value. The limestone is exposed in three quarries.

On the south of Kiln Cottage dark-grey calc-veined, more or

FIG. 13—QUARRY SOUTH OF KILN COTTAGES, NEAR BROADHEMPSTON.



less crinoidal, thin-bedded limestone is exposed to a depth of 20 feet, but the beds are thrown into sharp zig-zag plications and, in one place, faulted. East of Elbridge Cottage thin-bedded bluish calc-veined limestones, partly shaly, are exposed to a depth of 25 feet. The only fossils noticed were crystalline crinoid joints. Here again the beds are plicated in sharp zig-zag folds, so that the true thickness is probably much less than half of the depth exposed. West and north of Broadhempston the slates are partly calcareous—perhaps also between Simpson and Torbryan Mill. North of Port Bridge, by the road to Beaston Cross, there appear to be traces of limestone in the slates. At twelve chains north of Kingston Barton signs of limestone beds in the slates were observed in a drain.

Champernowne's map shows limestone trending south-west to some springs on the south of Sparkwell Cottages. An old pit east of Sparkwell also suggests the presence of limestone. The patch shown on the map is merely meant to emphasize these slight proofs of calcareous beds, which could not (as in the case

of the broad band south of Broadhempston) be shown otherwise than by lines, within which limestone may be sparingly, present in the slates At ten chains south-east of Kingston Barton, beds of crinoidal limestone dip in a south-easterly direction, but cannot be traced along their strike. On the south of Bow Bridge blue-grey slates, with veins of calc-spar and occasionally of quartz, are exposed in quarries. The dip of the schistosity varies from an easterly to a south-south-east direction. Further south, a thin brown band in the slates between Waddons and Waddons Cross suggests decomposed limestone. At a quarter of a mile south of Sparkwell an inacessible pit, filled with water, affords no evidence, but about ten chains further south (near Barntonhill Cross) slate with occasional limestone lenticles has been quarried. West of Barntonhill Cross, probably in line of strike with the above, bluish grey shaly limestones, associated with calcareous slates, are exposed in a quarry. South of this, bands of igneous rock occur in the slates in three places; but beyond the actual exposures they cannot be traced; near one of them, east of Fursdon, there is a pit in dark bluish grey shaly limestone in irregular laminæ, or beds, thickening in places from an eighth of an inch to three inches. The laminæ are contorted, pyrites is disseminated in cubes. Fossils are scarce and difficult of extraction; *Streptorhynchus* was noticed. These limestones, and calcareous manifestations, and the traces of igneous rock are probably parallel bands.

Fossiliferous brown lenticles occur in the slates west of Staverton. On crossing the Dart on the south of the village, there is a small patch of felsitic rock in the slates in the river bank.

A mass of igneous rock occurs on the hill north of Sparkwell. Torcorn Hill (on the north margin of the map) is capped by two patches of igneous rock; in the larger, porphyritic dolerite and sheared amygdaloidal rocks are exposed. At Well House and Houndhead, on the south side of Broadhempston, a small patch of igneous rock (tuff ?) is visible. There may be a patch on the west of Simpson. These may be connected with the igneous rocks of Coppa Dolla on the north (in Sheet 339).

On the east of the Ambrook patches of tuff, or schalstein. occur on the borders of the limestone of Newhouse Barton, and near the borders of the Ipplepen mass south of Orley Common.

At Newhouse Barton the limestone is shaly. Its northern boundary is a fault. The limestone of Yarneford Copse is faulted against the southern end of the Ipplepen mass; the lower beds seem to be intercalated with red slates. The limestones are exposed in a quarry north of Eastwell Barn; they seem to be much contorted. *Actinostroma Hebbornense*, Barg., indentified by Nicholson, was obtained in them. These limestones probably occupy inverted and faulted synclines in the slates, and the Battleford Copse limestone may be placed in the same category. They may therefore be regarded as a continuation of the lower parts of the Ipplepen limestones.

The Ipplepen quarries near Barton House exhibit 50 to 60 feet of grey and bluish, red-veined, limestone, intersected by calc-spar

filaments, etc. The beds are of irregular thickness, in places furnishing blocks 12ft. × 4½ft. × 3ft., furnishing ornamental marble on being polished. No organisms were obtained, In one part the rock is of a dolomitic and saccharoid aspect, stained blackish (probably by umber or manganese). It has been dissolved in a large irregular pothole which was filled with clay and stones. This soluble character recalls parts of the Brixham mass. A few chains north of Barton House, compact shaly reddish limestones, traversed by a thrust fault, are exposed. Further west, near the borders of Orley Common, brown stained dolomitic limestones have been quarried. *Caunopora ramosa* was obtained in one of the quarries, and *Cyathophyllum vermiculare*, Goldf. identified by Professor Frech.

Between Barton House and Yarneford Barn grey limestones, partly crinoidal, partly of a saccharoid dolomitic aspect, are exposed. On the margin of the limestone, thin-bedded crinoidal limestones are exposed on the south of Orley Common, and below Orley Quarry where they are associated with red slates. West of Well Barn there are lenticles of limestone in the slates, and shaly limestones occur west of Wood Barn; these beds are apparently at the base of the Ipplepen mass, and above the slates on the west; they may be represented by reddish crinoidal limestones which crop out at the Wellington Inn, Ipplepen.

On Hannaford Hill and in Beltor Quarries pale grey limestone apparently unfossiliferous, form a mass, probably separated by denudation from the Ipplepen limestones; cut off by fault on the south along Edgelands Lane; and elsewhere overlying slates, with traces of volcanic rock east and south of Wrigwell Cross, and with a patch of igneous rock and a trace of limestone near Blackstone. Near Combefishacre Bridge there is another trace of volcanic rock in the slates.

Between Combefishacre Bridge and Bulleigh Barton there are three masses of limestone. The westernmost is exposed in the railway cutting on either side of Wrigwell Bridge. Commencing on the east, we encounter tolerably thick even-bedded limestones, with intercalations of shale and thin-bedded limestone; these may be faulted against slates, on the east, in which there are traces of tuffs at Cockleford Bridge. If not reduplicated by contortion these beds would be about 50 feet thick; they are succeeded on the west by about 15 feet of thin-bedded limestone and calcareous shales with occasional thicker beds of limestone, on about 30 feet of reddish shales with thin beds of limestone and occasional impersistent thicker beds. The face of Wrigwell Quarry is along a fault, marked by limestone breccia. At about twelve chains north of Wrigwell Quarry a well was sunk to a depth of 30 or 40 feet, without obtaining water, in reddish and grey slates and shales, partly calcareous, and associated with shaly limestones and occasional impersistent limestone beds. On the west of the well shaly limestone is exposed overlying slates. The calcareous beds are probably cut off by a west-north-west fault, on the north. South of the railway the bedded limestones form Wrigwell Hill, and in Hoster Wood Quarry exhibit an inverted anticline.

Between Wrigwell Quarry and Kittymore Linhay a small patch of limestone, containing *Pachypora cervicornis*, seems to rest on, and pass downward into, chocolate-red slates.

The beds penetrated in Dainton Tunnel are dark slates with bands of tuff. Tuffs are evidenced in the slates near Dainton Elms Cross and Bulleigh Elms Cross, and in the cutting at the southern end of the tunnel, where the slates are also fossiliferous and contain limestone lenticles.

The tunnel is apparently traversed by a fault which forms the eastern boundary of the mass of limestone on the south. This limestone is separated by greenish slates from the Wrigwell mass. Near its eastern margin alternating thin and thicker even beds of limestone, with a south-easterly dip, are exposed in a quarry. A quarry in the south-eastern part of the mass showed thin even-bedded, dark grey, calc-veined limestones sharply inverted. They contain *Heliolites porosus*, *Favosites cristatus*, and *Actinostroma verrucosum*, identified by Professor Frech. The dip is in a north-easterly direction. Near the north-eastern border grey and bluish-grey coralline limestone is exposed, containing *Pachypora cervicornis*, *Striatopora denticulata* and *Smithia Hennahi*. Near this, on the west, *Stromatopora concentrica* and *Caunopora* were obtained. The centre of this limestone mass consists of slates with intercalated thin beds of limestone; these may indicate an upward or downward passage into slates.

In the third mass, near Bulleigh Barton, from 40 to 50 feet of even-bedded limestone, dipping south-east, at 25° to 30°, is exposed in a quarry. At six chains to the north of this, *Pachypora cervicornis* was found in limestone dipping east at 15°. The eastern boundary of this mass also appears to be a fault which, prolonged, forms the western boundary of the adjacent mass on the north. The latter is well exposed near Dainton Bridge, and is faulted against the Whiddon and Kerswell Down (in Sheet 339) mass at its north-eastern extremity.

The schalsteins, tuffs and slaty green basic rocks of Blair Hill and North Whilborough are, no doubt, a development of the same general stage of vulcanicity denoted by the tuffs near Ipplepen, Bulleigh, Elms Cross, etc., and are below the limestone on the north margin of the map. This limestone (the Whiddon and Kerswell Down mass) is pale-grey, whitish, pinkish, and compact, and resembles the higher parts of the Brixham and Torquay masses.

The slates which bound the volcanic rocks on the south contain fossils, amongst which *Retepora repisteria* was recognised; *Streptorhynchus* and other Brachiopods are to be found in them between Bulleigh Cross and Bickley Pond. Stellate sponge spicules (?) were noticed in Mill Lane near Compton Mill, and in Windmill Lane, further east, *Phacops*, *Streptorhynchus*, and Crinoids.

The Whilborough limestones commence in Windmill Lane, where a small patch passes down into slates with brown

fossiliferous lenticles. This patch seems to be shifted by fault about ten chains eastward, whence the slaty beds continue northward, the thicker limestones disappearing, unless shifted by fault to South Whilborough.

At South Whilborough dark grey even-bedded limestones, veined with calc-spar, shaly in part, and intercalated with shales, are exposed in a quarry. They are much contorted, being in part vertical and furnishing easterly and southerly dips.

CHAPTER V.

UPPER DEVONIAN.

Prior to 1889 the occurrence of Upper Devonian strata in the area was proved by Mr. J. E. Lee's discovery of the Büdesheim fauna, in red mudstones faulted against Lower Devonian rocks in Saltern Cove. Petit Tor Combe had always been considered as an example of anticlinal structure, the red slates in the centre being overarched by the limestones on either side, in De la Beche's sections. The inverted junctions of red slates with the Ilsham limestone, and in Elbury Cove, south of Paignton, with the Brixham limestone, had been regarded as natural junctions. The presence of Upper Devonian rocks in these localities has been proved by the discovery of fossils, by corresponding lithological characters, and by the working out of the stratigraphical relations. The lower zone of the continental Upper Devonian, characterised by *Rhynchonella cuboides*, cannot be separated out, and so the upper part of the limestone masses, which, no doubt, represent it, have been included in the descriptions of the Middle Devonian in the previous chapters. In the Lummaton limestone, where *Rhynchonella cuboides* is plentiful, *Stringocephalus* has also been found, but in the Petitor, Ilsham and Devil's Point limestones, and the limestone beds of Saltern Cove, Goodrington, Goodrington Park and Elbury, which are homotaxeous with the zone of *Rh. cuboides*, that fossil has not been found.

Petit Tor Combe.

Petit Tor is a boss of grey coralline limestone which descends to the beach in a cliff, separating New Red rocks on the summit from red slates at its base. On the face of this wall of rock patches of irregularly shaly, liver-coloured, limestone are occasionally met with. These resemble the Lower Dunscombe *Goniatite* limestone, and a diligent search was rewarded by the discovery of *Goniatites sagittarius* in them. The limestones on the opposite, or southern, side of the Combe are irregularly flanked by similar shaly limestones associated with red slates, here also, *Goniatites* were found. The grey limestones have here an appearance of nearly horizontal bedding, apparently due to planal cracks, or movements, traversing vertically zig-zagged bedding, and nipping in pieces of the liver-coloured *Goniatite* limestone. The soft red greenish-spotted slates, near their junction with the limestone, exhibit gently inclined cleavage dips, the bedding being indicated by vertically undulating greenish bands. These slates form the low cliff by the beach;

their association with the massive limestone, on the south, is so irregular as to suggest severed masses of limestone squeezed into them.

The structure of Petit Tor Combe* is therefore clearly a syncline of Upper Devonian Slates, irregularly based by shaly *Goniatite* limestones, and in direct, but contorted, relation to limestones equivalent to the upper part of the zone of *Rhynchonella cuboides*.

Anstey's Cove and Ilsham.

The limestone of Devil's Point, on the north side of Anstey's Cove, seems to be faulted against red and greenish slates with irregularly lenticular red shaly limestone associated with calcareous tuff. The cliff under the Ilsham limestone is composed of red and greenish slates containing *Posidonomya venusta*, and *Entomis serratostriata* (identified by Prof. Rupert Jones). On the borders of the Ilsham limestone, compact, irregular, shaly, reddish, whitish and greenish limestones are found. They are the representatives of the *Goniatite* limestones of Lower Dunscombe, and of Petit Tor. Compact concretionary limestone (the *Kramenzel* of the Continent) also occurs in the slates, which contain friable nodules (the *Knollen Kalk*) in places. The concretionary limestone is well shown on the border of the grey limestone, near Stoodly Knowle, behind the barn of Ilsham Manor, where it rests on red and green slates. North-east of Ilsham Manor the slates exhibit spilositic alteration near a patch of diabase, not far from the Black Head mass. A small patch of diabase also occurs on the west of Ilsham Manor, but there is no evidence for the continuation of the Upper Devonian slates between the Ilsham and Asheldon Copse limestones.

De la Beche† figured a section on the coast near the northernmost projection of Black Head, rather more than a quarter of a mile north of Smugglers' Cove. In a distance of about 130 yards (see Fig. 14) a projection, at the foot of the partly overgrown cliff-slope of the diabase, is formed by a mass of grey, yellowish-weathered, fine-crystalline limestone, from 20 to 30 feet in thickness, containing *Alveolites*, *Cyathophyllum cæspitosum*, and *Stromatactis*. The limestone is intersected by a fault with a south-east downthrow of a few feet, from which it dips steeply toward the south-east, and exhibits a greater thickness than on the other side of the fault. It is here overlain by compact, knubbly, and thin shaly, limestone, identical with types of the *Goniatite* limestones. In this a badly preserved *Goniatite* was found. These materials, in association with purple and green schalstein, or calcareous tuff, and seams of limestone, pass up into red and green slates, or slaty shales, overlain by indurated dark grey and green slates at, and near, contact with the diabase, both rocks being intersected by calc-spar veins. These Upper Devonian slates attain a thickness of 10 feet or more, at the sea

* See Fig. 15, page 109.

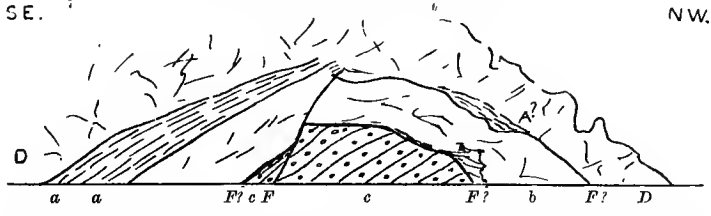
† "Geological Manual," 1832. 2nd Edit., p. 496.

level, but they attenuate rapidly upward, between the diabase and the limestone. On the north-west side of the fault the lower beds of the slates associated with the calcareous tuff and compact limestone seams and lenticles, are only partially (a') visible on the surface of the limestone, which is in contact with the diabase projection at the sea level.

On this side of the fault the limestone rests somewhat irregularly on (c)—buff, purple, and green schalsteins, full of pieces of compact reddish and grey limestone, near the junction, and containing seams, impersistent bands, and (coralline ?) nodules of limestone lower down. The upturned edges of the schistosity, which seems to be the bedding planes of the schalsteins, are cut off by the limestone above, so that the junction seems to be a fault, or thrust, which has been shifted by the fault that traverses the limestone, so as to allow very little of the schalstein to appear

FIG. 14. NORTHERN POINT OF BLACK HEAD.

(Length of section about 6 chains).



a. Dark grey and green slates or shales indurated at, and for a few feet below, contact.

a and a? Red and green slates and slaty shales, with occasional limestone seams, and purple and green schalstein, or calcareous tuff. At or near contact with b, compact knubbly limestone, and thin shaly limestone represent the Upper Devonian *Goniatite* beds

b b. 20 to 30 feet of grey fine-crystalline limestone with corals, weathering yellowish.

c c. Buff, purple and green schalsteins, full of pieces of compact reddish and grey limestone near junction with b, and containing, lower down, seams and impersistent bands and nodules (? corals) of limestone.

D D. Diabase.

F. fault. F? Apparently faults or thrusts.

above the water level on the south-east side. The limestone and overlying *Goniatite* beds and slates are probably separated from the diabase above by a fault, or thrust. These strong probabilities of displacement render the actual relations of the limestone to the diabase above, and schalsteins below, very doubtful.

The signs of schalstein above the limestone, here and in Anstey's Cove, prove that the emission of the diabase took place on the outskirts of a volcanic region, which was active during the deposition of the *Goniatite* beds. It is possible that the smaller patches of diabase were vents from which the Black Head mass flowed, its eruption being heralded by showers of ash, incorporated with the *Goniatite* beds, and that earlier eruptions, put a stop to the growth of the Ilsham coralline limestone for a time. In other words, the thick limestone bed in

this section seems to represent the latest stage in the growth of the Ilsham limestone, and before this the schalsteins beneath it had put a stop to its growth for an unknown period. This is analogous to the Saltern Cove succession.

Saltern Cove.

At five chains north of Saltern Cove a mass of New Red breccia rests unconformably on red shales and grits of the Lower Devonian. These are faulted against chocolate-red, broken, and contorted slaty mudstones of the Upper Devonian. The fault, owing to talus, etc., is not clearly seen, either in the cliff or in the adjacent railway cutting, and further west the evidence is very unsatisfactory. Proceeding southward along the coast, a nearly vertical wall-like mass of limestone-nodules, or flat ovoid lenticles, is encountered in the mudstones, the longer axes of the lenticles are tilted east 40° north, at an angle of 15°, which represents cleavage. Near this, at a few feet above the beach, the small *Goniatites*, *Bactrites*, and *Cardiolæ* of Büdesheim type are found. A little promontory separates this part of the coast from Saltern Cove; the slaty mudstones, of which it is composed, are in places thickly studded with irregular patches or lenticles of limestone; here also the characteristic fossils are to be found.

Mr. Lee's list* obtained from these places is as follows:—

Goniatites auris, *Quenst.*=Tornoceras auris.
G. retrorsus, *Quenst.*=T. simplex, *v. Buch.*
G. Ausavensis, *Stein*=T. Ausavense, *Stein.*
G. prinordialis, *Quenst.*=Gephyroceras orbiculus, *Beyr.*
G. Gerolsteinus, *Stein*=Geph. calculiforme, *Beyr.*
G. prumiensis, *Stein.*
Orthoceras Schlotheimi, *Quenst.*
Pleurotomaria turbinea, *Stein.*
Mytilus priscus, *Stein.*
Cardium palmatum (Cardiola retrostriata).
Crinoidal stems.

A fault runs parallel with the railway along the inner cliff face of the cove, shifting the beds exposed in the railway cutting seven chains northward on the beach. In the railway cutting the red mudstones become intercalated with thin even beds of limestone, and rest on a mass of coralline limestone containing *Pachypora cervicornis*. On the beach this limestone is seen to rest on tuffs and schalsteins with limestone fragments, as already mentioned in the Middle Devonian chapters. Here we have, as at Black Head, *Goniatite* beds—on coralline limestones—on schalsteins; the two cases, but for the Black Head diabase mass, would be exactly parallel.

The Upper Devonian slates certainly extend westward for more than half a mile from the coast. *Entomis serratostriata*, identified by Prof. Rupert Jones,† was found in them, but,

* *Geol. Mag.*, 1877, p. 102.
† *Ann. and Mag. of Nat. Hist.*, 1890, p. 319.

although the coralline limestone is present, no signs of the Büdesheim fauna have been detected in this direction.

Elbury and Silver Cove Coast.

The cliff in Elbury Cove is 30 feet high, and composed of red slates which appear as if they dipped under the Brixham limestone, whilst on the north they overlie a series of contorted thin-bedded limestones with intercalated seams of red mudstone passing down into the limestone of Elbury, which may be the top of the Brixham mass. Following the coast from Elbury Cove eastward, nothing is visible but the contorted grey limestone for a distance of fourteen chains, when we encounter contorted limestone beds intercalated with slates, inverted over red mudstone full of lenticles of red limestone (partly crinoidal). The lenticles sometimes occur in beds, as described near Saltern Cove. These beds are, here and there, intersected by veins of quartz and contain irregular masses of quartz, and of limestone partly replaced by quartz. A thick bed of limestone, intensely contorted, forms a noticeable feature in the section. In one place a band of contorted slate, a foot in thickness, marks a thrust plane. A careful search in the (inverted) lower part of the cliff revealed crushed *Goniatites* and *Bactrites*, and very good examples of *Cardiola retrostriata* (*Cardium palmatum*).

Between this section and Silver Cove the cliff, for about 60 yards, is composed of massive grey limestone, which forms also the eastern shoulder of Silver Cove. The centre of that cove consists of the same red beds, much fractured and contorted. They run inland from the top of the cliff for thirteen chains, flanked on either side by massive limestones. A north and south fault, shown at Ivy Cove, shifts them northward, but they continue from it eastward, for a distance of thirty chains, on the limestone plateau. In this extension the red slates seem to be associated with schalsteins, or felspathic tuffs.

In Fishcombe Cove red slaty mudstones, associated with tuffs, are wedged into the grey limestone by faults, and also form a narrow band running for some distance westward from the coast. No fossils have been found in the red slates west of Elbury Cove; felspathic tuffs, as already mentioned, occur in them in places, but, as elsewhere explained, it is impossible to distinguish slates above the Goodrington limestone from slates below it, without stratigraphical evidence of the presence and persistence of that limestone.

CHAPTER VI.

NEW RED SANDSTONE SERIES.

The interval between the deposition of the Upper Devonian and the accumulation of the basement clays, breccias and conglomerates of the New Red series is everywhere marked by a great unconformity. At Marychurch and west of Torquay the New Red rocks rest on Eifelian and Middle Devonian slates and limestones; at Cockington and in the Paignton district upon Lower Devonian strata.

Derivation.

The New Red rocks of the area are for the most part of strictly local derivation. The clays of Petit Tor and the fine breccia associated with them occupy the lower ground on the north margin of the area, and are distinguished by a lighter tint on the map, as far as the Compton Castle valley; although it is not possible to trace them further as a distinct series, it must not be inferred that they are necessarily elsewhere overlapped by higher beds, but simply that they are no longer lithologically distinguishable.

The Upper and Middle Devonian slates furnish a ready source of derivation for these beds. The name, Watcombe clays, has been given to them from the fact that the celebrated Watcombe ware is manufactured from the puddled clay obtained from them * at the head of Watcombe Combe. The coarser New Red beds consist of conglomerates and breccio-conglomerates—with fragments of Devonian limestone, grit and slate, and of igneous rocks, in a sandstone matrix, and with intercalated beds of sandstone—and of breccias with fragments of grit, slate and limestone, or of grit and slate, or of slate only, in sandy or loamy matrices. In every variety the source of derivation of the majority of the included fragments, and the local character displayed by the rocks, may be traced to the neighbouring Devonian limestones, grits and slates.

As regards the igneous fragments, more especially in the cliff-sections, doubtless many might be found which could not be traced to exposed sources within the present coast limits of the district.

The variability of the New Red rocks renders the tracing of faults in them a rather unprofitable task, but that such variability may be locally due to the faulted conjunction of different horizons is rendered probable by the frequent instances of faulted boundaries with the older rocks, and by the numerous small faults shown in the coast sections. Faults run in many directions. Those running north and south are evidently the latest, but there appear to be north and south faults affecting

* W. A. E. Ussher, on "The Age and Origin of the Watcombe Clay," *Trans. Devon. Assoc.* for 1877.

the Devonian only (viz., east of Aptor). The high dips locally observable in the New Red, as in Oddicombe Beach cliffs and at Petit Tor, are always accounted for by the proximity of faults.

Watcombe Clays.

The Petit Tor section exposes lower beds of this series than those in Watcombe Combe; these consist of red clays, or shaly marls, with beds of sand (an argillaceous paste of comminuted slate fragments), and of rubbly breccia at junction with the Devonian limestone. The clays are cut off against the newer conglomerate by fault. The Oddicombe Beach New Red rocks are faulted on both sides. They consist of breccia, breccio-conglomerate, and sandstone, intercalated irregularly, and evidently belonging to the beds above the Watcombe clays.

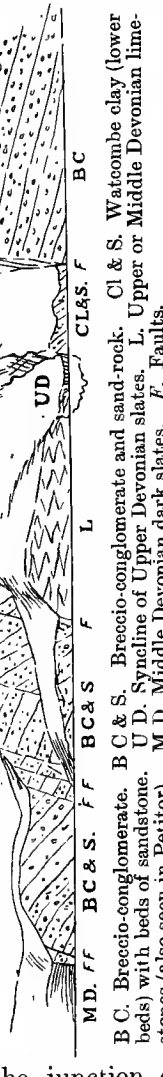


FIG. 15. PETIT TOR (horizontal scale 6 inches = 1 mile. Approximate vertical scale 1 inch = 800 feet).

B C. Breccio-conglomerate. B C & S. Breccio-conglomerate and sand-rock. Cl & S. Watcombe clay (lower beds) with beds of sandstone. U D. Syncline of Upper Devonian slates. L. Upper or Middle Devonian limestones (also seen in Petitor). M D. Middle Devonian dark slates. *F*. Faults.

On the south-west side of Torquay cemetery, the brick pits at Old Wood exhibit sections of dark red-brown, or purplish-brown, clunchy clay mixed with masses of sand, or very fine breccia, made up of comminuted Devonian slate. Here and there beds, or lenticles, of red clay containing fragments of Devonian limestone are intercalated. In one spot the beds appear to be faulted, and present a south-west dip of 35°

From their junction with the overlying breccio-conglomerates and breccias in the Torre Railway cutting westward, the boundary of the Watcombe clays becomes more and more indefinite; the lines drawn for them near Whilborough and Compton Pool merely separate distinct conglomerates and breccias, from breccia with a more or less clayey and loamy matrix, which occupies the lower ground, and is very partially exposed. Further to the west, the junction of New Red with Devonian is much obscured by rainwash on the slopes. Near Combe Fishacre the breccias are clayey and loamy in places, but this character is often observable elsewhere, and there is no proof that it denotes any special stratigraphical horizon.

Conglomerates, Breccias, etc.

The conglomerates are finely exposed in Petitor Crags. In the Oddicombe cliffs the well-rolled limestone pebbles are less frequent, the rock more often presenting the appearance of breccia, or breccio-conglomerate, with beds of sandstone, which exhibit an irregular surface in places, the breccia filling hollows probably due to slight contemporaneous erosion. Conglomerates with large limestone pebbles occupy the high ground south of Whilborough; they are associated with breccio-conglomerate and breccia, the latter varieties prevailing to the west of the Compton Valley. The New Red, where limestone fragments are absent, sometimes presents a rubbly appearance with indistinct bedding, in colour much resembling the Lower Devonian grits and shales on its borders; as in the outlier south of Marldon, at and near Occombe, south-east of Marldon, in the outlier at Blagdon Cross, on the west of Collaton Kirkham, etc. An outlier is shown on the map between Occombe and Hollicombe, north of Paignton, which, not being exposed in section, is doubtful; the resemblance between the rubbly New Red gravelly soil and that of the Lower Devonian being very close. At Collaton Kirkham red-brown loam studded with fragments of Lower Devonian rocks, mostly small, represents the New Red breccia.

The coast sections at Corbon's Rock and Livermead show intercalation of sand-rock in breccia, or breccio-conglomerate, and brecciated sand. In Corbon's Rock beds of yellow and grey sand-rock are faulted against breccio-conglomerate, which is in its turn faulted against breccio-conglomerate upon yellow and grey sand-rock. On the north of Livermead breccio-conglomerate rests on red-brown, red, and occasionally grey, sand, with seams of breccia, over breccia or brecciated rock-sand. The limestone fragments on this part of the coast are often coated with the peculiar annulated form of chalcedony called beekite.*

In the railway cutting across Roundham Head red sand, with buff and grey patches and a clayey band, rests on conglomerate with numerous limestone fragments affording many examples of beekite structure. A quarry near Paignton Quay shows purplish red grey-mottled loam—on thin even-bedded red grey-mottled sandstones—upon breccio-conglomerate; separated by faults from brown-red loamy breccia with seams of red sand—on reddish sand and loam, brecciated in places, on one side; and from purplish red grey-mottled loam with thin even-bedded red sandstones—on breccio-conglomerate, on the other. On the south side of Roundham Head (Fig. 16) the association of beds of rock-sand in breccia and breccio-conglomerate is very marked. The general dip is northerly, so that the beds on the north side of the Head are doubtless above these; they are brecciated sand and loam, with thin even-bedded sandstone, and breccio-conglomerates.

---

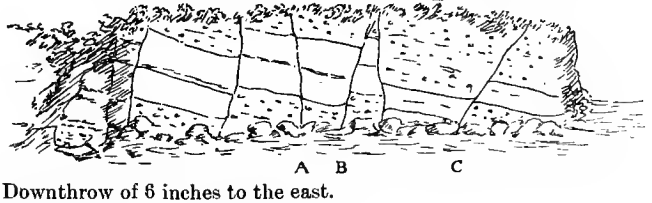
* Vide Pengelly, *Trans. Roy. Geol. Soc. Corn.* vol. vii., p. 309, and *Rep. Brit. Assoc.* for 1856, *Trans. of Sections*, p. 74; also Pengelly, "The Geology of the North-Eastern Coast of Paignton," *Trans. Devon. Assoc.* for 1878.

A quarry on Primley Hill shows red-brown bedded breccio-conglomerate dipping north at about 13°. In some parts stones of limestone and quartz predominate, in others, fragments of grit and lydian stone (or dark blue-grey fine slaty rock). The matrix of coarse sand is largely composed of comminuted slate. A large quarry, 50 feet in depth, in an orchard on the north-west of Paignton, shows rubbly brecciated loam and hard beds of brecciated sandstone for 15 feet from the surface, upon thick beds of breccio-conglomerate, some of the beds being 2 feet in thickness; the matrix consists of comminuted grit and shale, or slate, and coarse sand.

On the west of Paignton the hard thick-bedded breccia and breccio-conglomerate is exposed in a quarry. The contained fragments are of limestone, quartz, grit, and a few igneous, angular, sub-angular and well-worn, in a hard red sand matrix. Within 15 feet from the surface strips of red sand occur, and quartz fragments predominate, limestone being more plentiful below. The above observations will show the futility of attempting to divide the New Red rocks of the Paignton area into stratigraphical horizons.

FIG. 16. CLIFFS ON THE SOUTH SIDE OF ROUNDHAM HEAD.

(Horizontal and vertical scale 1 inch = 120 feet)



A. Downthrow of 6 inches to the east.
B. Downthrow of 6 feet to the west.
C. Downthrow of 7 feet to the west. Faults shown by displacement of beds of sandstone in breccia and breccio-conglomerate.

Near Paignton Cross, by the side of the road leading to Goodrington Sands, nearly horizontal beds of red sand with bands of coarser sand, or of fine breccia, containing worn fragments of igneous rock, are exposed. There is a trace of breccio-conglomerate on the Devonian slate reef in the middle of Goodrington Sands. Further south the unconformity of the New Red on the Devonian is well shown on the coast. A fault which runs coincidently with the Broad Sands Coast cuts off a projection and coast reefs of New Red sand-rock with bands of breccio-conglomerate; at the southern extremity of the patch the sandstone is indurated and intersected by numerous calc-spar veins in proximity to the fault. Further south, on the west side of Galmpton Point, two very small patches of breccio-conglomerate occur on the beach.

Mr. A. R. Hunt discovered a trace of New Red breccia on a rock reef platform near Compass Cove, south of Dartmouth Castle. The extension of the New Red beyond its present limits over the Devonian area is also proved by traces of its former

presence in small outliers, or in potholes and fissures in the Devonian limestone, in the following places:—

At half a mile north of Stoke Gabriel a small patch of red sand and sandstone occurs on the limestone; in its vicinity red and brown loam with slate fragments masks the surface of the limestone.

On the north of Waddeton a red clay soil with pieces, and occasional boulders, of hard New Red sandstone, here and there, suggests an outlier or the remnants of an outlier. Near this, on the east, there are signs of two small outliers of New Red sandstone on limestone.

In the quarry by the high road near Goodrington, and in two places in the railway cutting north of Broadsands, there appear to be pockets in the limestone filled with New Red materials.

In the Brixham limestone at Ivy Cove, near Fishcombe Point, at Berry Head, etc., vertical veins and dykes of hard red sandstone fill cracks and joints in the limestone.* They suggest the subsidence of New Red sand into lines of weakness, enlarged by the percolation of acidulous water, by which the infillings were cemented in the cracks. Some blocks of the sandstone occur on the summit of the limestone plain west of Fishcombe Point, and also near the Ropery and Paint works not far to the west of Brixham Station, where also sand and brecciated loam fill fissures and potholes in the limestone. There are similar traces between Brixham and Durl Head. Near Durl Head a small patch of New Red sandstone is shown on top of the cliff (*vide* map). On the west end of a narrow indentation, north of Durl Head, a trace of the sandstone (too small to indicate on the map) is visible.

The hard sandstones above referred to are similar to those which occur at the base of the New Red at, and near, Bishopsteignton. Beyond these proofs of the extension of New Red rocks over the Devonian limestone plateaux, there is no evidence to show that they ever covered the higher lands of the Lower Devonian in the south of the map.

The absence of signs of contemporaneous vulcanicity in the New Red rocks of the area is accounted for, by their evident attenuation through a conformable overlap, as they are traced northward toward Exeter, the volcanic horizon being higher in the series than the strata represented in the map.

Mr. Hunt's dredging operations in Torbay led him to conclude †: "The sunken limestone and slate rocks of Torbay prove also that where they exist the Triassic sandstones, which by the position of their remains appear to have formerly filled the greater part of the bay, can never have been present to any great depth."

---

* *Vide*, Pengelly, "On Certain joints and dikes in the Devonian Limestones on the Southern Shores of Torbay," *Geol. Mag.* for 1866, pp. 19–22.

† "Notes on Torbay," *Trans. Devon. Assoc.* for 1878.

CHAPTER VII.

POST-TERTIARY AND RECENT.

Under this head are embraced cavern deposits, raised beaches, 'Head' or ancient talus shed on the old beach plane, submerged forests, fluviatile deposits comprising river terrace gravels, etc., and the more recent alluvial flats.

It is, of course, impossible to indicate the cavern deposits on the map, and as regards superficies the raised beaches and the submerged forests which are occasionally visible on the foreshore cannot be shown, yet these phenomena are well represented within the area embraced by Sheet 350. The indefatigable labours of the late W. Pengelly in the Torquay and Brixham caves have rendered them notable throughout the scientific world. Godwin-Austen, Mr. A. R. Hunt, and others have attracted an especial interest to the raised beaches of the Torquay promontory and its vicinity, and the researches of Mr. A. R. Hunt in submarine geology in Torbay, in carrying on the investigations of the late W. Froude, further contribute to the exceptional geological interest attaching to this map.

Cavern Deposits.

The facilities which the faulted, jointed, and contorted limestone masses of the district afford for the downward percolation of surface waters have resulted in the widening of joints and fissures into subterranean galleries, shafts and chambers. Into these, materials have been introduced from outside between, or during, periods of precipitation of calcareous matter in solution in percolating water which, dripping from stalactitic incrustations and protuberances, formed stalagmitic floors. Two fine examples of such caverns occur in the district, *viz.*, Kent's Hole, Torquay, and Windmill Hill Cavern, Brixham. Besides these the Happaway Cavern in Stentiford's Hill, Torquay, and the Anstis Cove Cave have been explored and described by Pengelly. It is probable that many more bone caverns have been dissolved in the limestones, which, through their apertures being choked up by limestone blocks cemented in stalagmite, have escaped detection; as the existence of the Windmill Hill Cavern, Brixham, was only accidentally revealed by quarrying.

Kent's Hole is situated in a wooded limestone hill on the south of Asheldon Copse, and on the south side of the road from Torquay to Ilsham. There are two entrances to the cave fifty-four feet apart,* on the eastern side of the hill and nearly on the same level. They are situated at about 270 yards due east of

* See "Lecture on the Ancient Cave Men of Devonshire," by W. Pengelly.

St. Matthias Church, and at from 60 to 70 feet above the bottom of the adjacent valley.

The following information is gleaned from "A Short Account of Kent's Cavern," by Mr. A. R. Hunt.* The cavern has many ramifications from two main parallel passages, the northernmost of which exceeds 300 feet in length. The entrance now in use is 184 feet above meantide level, and was blocked by *débris* when the systematic explorations began in 1865.

The cavern was first explored by the Rev. J. McEnery in 1825. His researches established the existence of numerous bones of extinct mammalia with worked flints. McEnery's MSS. notes were subsequently published by Pengelly. The cavern was investigated by R. A. C. Godwin-Austen in 1840, and a small part of it by the Torquay Natural History Society in 1846. The systematic exploration of the cavern by the British Association, commenced in 1864 under the superintendence of Mr. Pengelly and Mr. E. Vivian, of Torquay, was continued without intermission until 1880, at a cost of more than £1,950. "When the Association began its work, three deposits only were known in the cave, *viz.*, a layer of black mould which rested on a floor of (granular) stalagmite, which in its turn rested on a bed of 'cave earth' of unknown depth. The method of exploration adopted was the removal of the stalagmite, whatever its thickness, with four feet of the subjacent deposit, the latter, in carefully numbered and recorded portions, three feet long, one foot broad, and one foot deep." In the fourth report of the Exploration Committee the discovery of a breccia of grit, stalagmite, and bones was announced, and, shortly afterward this breccia was found to be separated from the overlying cave earth by a local floor of crystalline stalagmite, which reached a maximum thickness of twelve feet.

"The breccia entered the cave from the west and thinned toward the east. The cave earth entered from the east and thinned toward the west. The true cave earth sometimes overlay the breccia; the breccia never overlay the cave earth." "The fauna of the cave earth included twenty-six species of mammalia," remains of hyæna being abundant. "That of the breccia consisted almost entirely of bears, with traces of lion, fox and deer." The flints of the cave earth were of two recognised palæolithic types, and were associated with implements of bone, "whilst those of the breccia were formed of flint nodules and chips struck off in the making."

Notwithstanding the exhaustive exploration of the cavern, the only plan of its ramifications extant is that drawn by Mr. A. R. Hunt, from every available material, for the guidance of the Geologists' Association, published in their Excursion Programme, 20th March, 1900. †

Probably the most succinct account of Kent's Cavern to be found amongst Pengelly's writings is furnished by the following

* Presented by the Torquay Natural History Society to the members of the British Association visiting Torquay, September, 1898.

† See also *Proc. Geol. Assoc.* vol. xvi., p. 437.

table, extracted from "Notes on Recent Notices of the Geology and Palæontology of Devonshire,"* in which the scientific names of the species found were not given.

Deposits.	Contents.
Black Mould	Stones of various kinds; shells of hazel nuts; shells of snails, limpets, whelks, oysters, cockles, mussels, pectens, solens and cuttle-fish; bones of birds, seal, water rat, rabbit, hare, goat, sheep, red-deer, shortfronted ox, brown bear, badger, fox, dog, pig, and man. "Whetstones," angular and curvilinear plates of slate; pieces of smelted copper; bronze articles including rings, a fibula, spoon, spearhead, socketed celt and pin; flint "strikelights"; potsherds (including a piece of Samian ware); stone "spindle-wheels," a bone awl, bone chisel, bone combs; amber beads; charred wood; a halfpenny of 1806; and a sixpence of 1846.
Granular Stalagmite.	Stones of various kinds, impressions of ferns; shells of cockle and cuttle-fish; bones of bear, mammoth, hyæna, rhinoceros, horse, fox, and man. Flint-flakes and "cores."
Black Band.	Bones of ox, deer, horse, badger, bear, fox, hyæna, and rhinoceros; 366 flint implements, flakes and chips; a bone awl, a bone needle or bodkin having a well-formed eye, a bone harpoon; burnt bones and burnt wood.
Cave Earth.	Bones of lion, lynx, wild-cat, hyæna, wolf, fox, *Isatis* (?), glutton, badger, cave bear, grizzly bear, brown bear, mammoth, *Rhinoceros tichorinus*, horse, wild-bull, bison, Irish-deer, red deer, hare, pika, water vole, field vole, bank vole, and *Machairodus latidens*. "Whetstones," hammer stone, lanceolate and ovate flint *flake* tools, flint flakes, and "cores"; a bone pin, two bone harpoons, charred wood and bones.
Crystalline Stalagmite.	Bones of bears.
Breccia.	Bones of bears of various species, including cave-bear; a very few of lion and fox. Flint *nodule* tools and flakes.

Happaway Cavern is situated in the limestone of Stentiford's Hill, Torquay, on the south-western slope overlooking the street at 271 feet above mean tide level. Pengelly † gives the deposits in descending order as follows:—

"1. Fine light chocolate coloured earth containing bones and bits of charred wood, but few stones, average depth about 6 inches.

2. Tenaceous moist dark coloured earth, with numerous bones, bits of charred wood and stones about 18 inches.

3. Coarse rather sandy brightish red earth with larger and more numerous stones, occasional limestone blocks and pieces of stalagmite. Charred wood and bones less plentiful."

Owing to the absence of separating stalagmite, the relative positions of the bones found are not certain. They consist of badger, deer, fox, pig, sheep, hare, rabbit, and smaller rodents, bat and man (human skull, bones, jaws), two parts of tooth of

* *Trans. Devon. Assoc.* for 1882, vol. 14, p. 694.

† *Trans. Devon. Assoc.* for 1886, p. 161.

rhinoceros, two molars of bear, one tooth of *Hyæna spelæa*, shells of cuttle-fish, a periwinkle and cockle valve, many of *Helix* one fish vertebra, a few bones of birds, and about 50 flint chips and flakes were also found.

Anstis Cove Cavern* is situated in the northern cliff face of the cove, three furlongs north-north-east from Kent's Hole. From M'Enery's Notes (1825) there is no reason to infer any evidence of an extinct fauna. The cavern is 63 feet in length, 9 feet high by 6 feet broad at its mouth, narrowing to 3 feet by 3 feet at the end. The downward succession of deposits seems to be :—

In one part	1. Angular *débris* encrusted with stalagmite	14 inches.
In another part	„ Stalagmite -	6 inches.
Upon	2. Stones, shells, teeth, and bones forming a compact breccia, containing shells of *Helices* and *Turbo* [*Cyclostoma*] *elegans*, fox's jaw and tusk, bears' tusks and teeth, one deer's horn, one young horse tooth, a few teeth resembling canines of hyæna, some slight long bones gnawed, probably by foxes -	about 1 foot.
Upon	3. A second stalagmite -	2 inches.

"The mammals which appear to have been generically identified are bear, fox, deer, and perhaps hyæna," species in no case stated.

Windmill Hill† rises to a height of 175 feet above mean tide level, eastward from the principal street of Brixham leading to the harbour. In January, 1858, in quarrying in the upper part of the hill, the crowbar disappeared down a small hole in a north and south joint. On further excavation the owner was enabled to descend and recover the tool, when he found that the vertical chamber communicated with a "long narrow tunnel" extending "southward for about 50 feet, whence a second gallery extended westward." The natural entrance, sealed up by angular limestone fragments cemented by stalagmite, was soon afterward opened up, whereupon a lease was negotiated with the proprietor for the purpose of systematic exploration by a committee under the auspices of the Royal Society and the Geological Society of London, which was begun in Midsummer 1858, and completed (at the end of one year) by Midsummer 1859. In September, 1858, the results obtained, up to that date, were communicated at the British Association Meeting held at Leeds. They are summarized as follows by Mr. Pengelly :—

"The deposits were, first or uppermost, a floor of stalagmite varying from a few inches to upwards of a foot in thickness. Several bones were found on and in the stalagmite," including "a fine antler of a reindeer firmly cemented to the upper surface," and "a humerus of the extinct cave bear lying completely within the stalagmite."

"Second, cave-earth composed of red ochreous loam and angular pieces of limestone, and containing rolled fragments of quartz,

* Pengelly. *Trans. Devon Assoc.* for 1873–4, vol. vi., pp. 61, etc.
† Pengelly. "The Ancient Cave Men of Devonshire."

greenstone and brown hematite of iron. Though deposits capable of yielding the rounded materials exist in the Brixham district, none of them could have been derived from Windmill Hill; nor could they at present reach it without crossing one of the deep valleys by which it is bounded." "The bones in the cave-earth were those of the ordinary cave-mammals," "an entire left hind-leg of the cave bear," was discovered by Dr. Falconer.

"Third, or lowest, gravel, mainly consisting of well-rounded fragments of quartz and greenstone, having a tendency to become a more or less firm conglomerate." "None of the very few bones" found "were of any importance." "Except in one limited locality, all the objects lay in such a position with regard to the plane of the cave-earth bed, as to betoken the action of a small stream of water which must have flowed continuously through the cavern in one uniform direction," "at a time when the bottom of the valley was at or near the level of the external entrances," "at a time so remote that the valleys of the district were at least one hundred feet less deep than they are at present."

Pengelly also states that the flint implements and flakes found were obtained "at from 9 inches to upwards of 20 feet below" the under surface of the stalagmite, the greater number being in the cave-earth; "whilst nearly 40 per cent. of all the bones met with were above the uppermost implement or flake." The full report of the committee's exploration may be found in the volumes of the *Philosophical Transactions*. The following is taken from Professor Prestwich's Report* to the Royal Society. "When first opened all the galleries and chambers were found to be more or less filled with the following deposits in descending order:—

1st. A layer of stalagmite, varying from a few inches to upwards of a foot in thickness.

2nd. Reddish cave-earth, with angular fragments and blocks of limestone in places, generally averaging from 2 to 4 feet. [In places completely choking the galleries up to the ceiling.]

3rd. Waterworn shingle 2 to 6 feet. [Pebbles of limestone, quartz, greenstone, grit and shale.]

In addition to these a thin layer of peaty or carbonaceous matter extended on the cave-earth from near the entrance to a distance of 40 feet, and was overlain part of the distance by a limestone breccia."

"A few pebbles, the same as those composing the underlying shingle bed, were occasionally found in the cave-earth, together with fragments of stalagmite, portions apparently of an old destroyed stalagmite floor."

"No shells were found in any of the beds, but a considerable number of existing land shells, and one limpet shell were found on the surface, and a few in the stalagmite. They were most numerous near the external entrances."

"Mammalian remains were found sparingly in the stalagmite, in abundance in the cave-earth, and rarely in the shingle." "No coprolites were found in any part of the cave." Omitting bones

* From "Report on the Exploration of Brixham Cave" *Proc. Roy. Soc.* No. 137, 1872.

"of small rodents, no doubt of comparatively recent introduction," "the bones belong to twenty or twenty-one animals, referred by Dr. Falconer and Mr. Busk to the following species":—

Elephas primigenius.	Capreolus capreolus.	Lepus timidus.
Rhinoceros tichorhinus.	Felis leo (var. spelæa).	L. cuniculus.
Equus caballus.	Hyæna spelæa.	Lagomys spelæus.
Bos primigenius ?.	Ursus spelæus.	Arvicola amphibius.
B. taurus ?	U. ferox (priscus).	A.—— ?
Cervus elaphus.	U. arctos.	Sorex vulgaris.
C. tarandus.	Canis vulpes.	

No tusks or teeth of mammoth met with, hence bones found probably brought in by carnivora. Remains of the woolly rhinoceros rather numerous. "Next to those of the Bear, the remains of the Reindeer are by far the most abundant," and next in abundance those of *Hyæna spelæa*. "Remains of the Cave Lion are scanty in number." "Not a single human bone has been found in Brixham Cave; but thirty-six rude flint implements and clips, "were met with in different parts of the cave." One of these is "a roughly-shaped flint hatchet." The implements were found in positions that prove the co-existence of man with the extinct mammalia.

Raised Beaches, etc.

Pengelly* draws the following inferences from a study of the raised beaches and submerged forests of Torbay etc.:—

1. "That the submerged forests are more modern than the raised beaches."

2. "That after the completion of the beach the entire district was uplifted at least 70 feet before the forest flora took possession of the soil which its remains now occupy."

3. "That subsequently to the forest era there was a general subsidence to the amount of certainly forty, perhaps of many more, feet."

4. "That the forests are of sufficient antiquity to have sheltered the mammoth and long-fronted ox, but that they fall very far short of the era of extinct molluscs."

5. "That the successive changes of level were at least tolerably uniform, and were effected gradually."

In the raised beaches of Hope's Nose and the Thatcher Rock the district possesses the best examples for the study of the molluscs of that period to be found in the south-west of England. The Hope's Nose raised beach has been described by many observers. Of these Godwin-Austen† was the first.

He gives the thickness of the stratified consolidated sand and underlying "conglomerate containing blocks of considerable size" as 17 feet, with an extension from east to west of not more than 50 feet, and the height of its base as 31 feet above high water.

---

* *Trans. Devon. Assoc.* for 1865, pp. 33, 34.

† *Proc. Geol. Soc.*, vol. ii, p. 102 (1834) and *Trans. Geol. Soc.*, ser. 2, vol. vi. p. 441 (1842).

Prestwich* describes it as "a projecting cornice overlain by three feet of sand and then by a few feet of angular local rubble in which" he "found a tooth of a horse. Many of the shells are entire, but they are mixed with a large proportion of comminuted shells."

Mr. Jukes-Browne supplies the results of his more recent investigations in the following notes taken in September, 1898:—

"This raised beach is at the south-eastern corner of the Hope's Nose promontory; its base is about 25 feet above what appears to be ordinary high water mark. It rests on an irregular surface of limestone, and its basement bed is from 12 to 16 inches thick, consisting of pebbles and large boulders in a matrix of coarse sand. The boulders are chiefly limestone and slaty rocks, mostly rounded, but some sub-angular, and they range up to over a foot in longest diameter. The material above this is a coarse sand, very regularly bedded, and cemented with carbonate of lime into a hard stone, which forms a projecting cornice. Here and there are softer places from which shells can be extracted, the commonest species being large and thick specimens of *Ostrea edulis*, *Mytilus edulis* and *Patella vulgata*, many of which are perfect though difficult to extract."

"This concreted sand contains some large stones and pebbles of local rocks, and it is noticeable that the lower foot or two consists largely of the *débris* of such rocks (limestone, slate, trap etc.), though quartz both in large and small grains is abundant and there is much comminuted shell. Higher up the quartz grains predominate and the sand becomes finer, though there are occasional layers of coarse sand with limestone and shell *débris* up to the top of the consolidated and unweathered portion of the beach, which is about 12 feet above its base."

"At the top it passes into soft loose sand, which is of very fine grain, and may be blown sand, but is probably as old as the beach sand below. Of this sand there is two or three feet, and it is overlain by sandy soil containing small angular rock fragments. This is hardly to be called 'head,' but is evidently soil and land wash from the slope behind, for the beach forms the top of the cliff, and the ground rises inland from it in a gentle slope of cultivated land."

"The following is a list of the shells which have been found in this beach by Messrs. Godwin-Austen, Prestwich, A. R. Hunt and myself":—

Cardium echinatum? (recorded as *tuberculatum* by Austen).
— edule (common, but rotten).
Cyprina islandica (Austen, Prestwich).
Mytilus edulis (very common).
Ostrea edulis (very common).
Pecten maximus (Austen).
— varius (not uncommon).
— sp. (Jukes-Browne).
Tapes decussata? (Austen only, as *Venerupis decussata*).
Littorina littorea (Austen and Prestwich).
— obtusata (Jukes-Browne).

* *Quart. Journ. Geol. Soc.*, vol xlviii, p. 279 (1892).

Littorina rudis (Prestwich, Hunt, Jukes-Browne).
Murex erinaceus (Austen and Prestwich).
Patella vulgata (common).
Purpura lapillus (not uncommon).
Trochus ziziphinus (Hunt).
Turritella terebra (Austen and Prestwich).

"Godwin-Austen mentions *Modiola vulgaris* (*M. modiolus*) and does not mention *Mytilus edulis*. The shells are large and have somewhat the aspect of *Modiola*, but are probably *M. edulis*. The umbonal end is generally wanting, and in most of them the inner shell is partially dissolved away. Mr. A. R. Hunt has also found the claw of a crab."

The Thatcher Stone is a small island of limestones, about 800 yards from the Hope's Nose raised beach in a direction south 32° west, but the nearest point of the mainland on the north is not more than 330 yards from it. There is a raised beach shelf, or platform, at from 10 to 15 feet above high water mark on the eastern side of the island, on which traces of raised beach and broken shells are to be found mixed with partially consolidated "Head" or ancient rubble. Mr. A. R. Hunt * found that "the portions of the beach deposit best preserved are on the northern shoulder of the rock facing the mainland." The site indicated is a higher part of the rock shelf, and disconnected from that on the east side of the rock. Mr. Jukes-Browne tells me that the "embedding material" of the beach "consists principally of quartz sand and comminuted shell, with many small fragments of slaty rock." The 43 species obtained by Mr. Hunt from the Thatcher Beach were identified by Messrs. Gwyn Jeffreys, J. T. Marshall and D. Pidgeon, and are as follows:—

Cerithium reticulatum.
Cylichna cylindracea.
Fusus gracilis.
— jeffreysianus.
Lacuna puteolus.
Littorina obtusata.
— rudis.
— litorea.
Murex erinaceus.
Nassa reticulata.
— incrassata.
Natica Alderi.
Patella vulgata.
Pleurotoma striolata.
— brachystoma.
— turricula.
Purpura lapillus.
Scalaria Turtonæ.
Trochus zizyphinus.
Trophon truncatus.
Turritella terebra.
Astarte sulcata.
Cardium echinatum.
— edule.
— Norvegicum.
Cyprina islandica.
Lutraria elliptica.
Mactra subtruncata.
Mya arenaria.
Mytilus edulis.
— modiolus.
Nucula nucleus.
Ostrea edulis.
Pinna rudis.
Saxicava rugosa.
Solen vagina.
Tellina balthica.
Venus exoleta.
— fasciata.
— gallina.
Adeorbis subcarinatus.
Aporrhaïs pes-pelecani.
Buccinum undatum.

Mr. Hunt singles out from the above *Trophon truncatus* and *Pleurotoma turricula* as evidence of a rather colder climate, the

* "The Raised Beach on the Thatcher Rock, etc." *Trans. Devon. Assoc.* vol. xx. pp. 225—252, 1888.

presence of *Pinna*, *Adeorbis* and *Fusus jeffreysianus* and the absence of *Astarte borealis* negativing the idea of any intensity of cold.

From the presence of the estuary-frequenting forms *Mya arenaria* and *Tellina balthica* and *Cardium edule*, the former extension of the mouths of the Teign and Exe, and a westerly drift from them, is suggested.

The absence of *Cardium aculeatum* from the raised beach, and its occurrence in the clayey and muddy bottom of Torbay, in view of the strong probability that the clay in Torbay is the seaward extension of the submerged forest clay deposited in a subsequent era to the raised beach, led him to infer that through lack of a congenial muddy sand bottom *C. aculeatum* was absent from the vicinity of what is now Torbay during the raised beach period.

"That the beaches on the Thatcher and at Hope's Nose were in one and the same little creek or bay is very evident." "But the stage of erosion indicated by the northern Torbay raised beaches" is, according to Mr. Hunt, prior to the excavation of Torbay, or in an early stage in its formation.

"The shell bearing remnant of the Thatcher beach is very insignificant in area. It is therefore improbable that any shell rare in the raised beach era should have been preserved in so small a deposit."

Godwin-Austen * first drew attention to the raised beach on the Thatcher, "rich in shells, particularly the *Turritella terebra*."

He also alludes to the occurrence of raised beaches near Brixham and Sharkham Point.

No reliable traces of raised beach are met with between Hope's Nose and Churston Cove. Opposite Churston Cove there is an old beach platform cut in (apparently) nearly horizontal limestones, on its irregular surface consolidated sand is visible in places adhering to the inequalities in the rock, and containing shells, mostly broken, of *Purpura*, *Littorina*, *Cardium edule*. The beach traces are partly mixed with earthy *débris*, or Head, containing fragments of limestone, which form a gentle slope below the 50-feet contour. At the Sharkham Point Iron Mine there is an old beach platform at 10 to 15 feet above high water. Amongst the mine rubbish with which it is covered are pieces of cemented sand composed of quartz and comminuted shells and containing small flint, slate and quartz, pebbles and sub-angular fragments, and occasionally large fragments of limestone, but the beach material was not exposed actually *in situ*.

Between Blackstone Rock and Compass Cove, south of Dartmouth Castle, traces of old beach sand are observable on a rock platform surmounted by Head. Further to the south, at Western Combe Cove, at about 15 feet above high water, an even slate platform, flush with the cliff at its edge, supports over 20

* *Trans. Geol. Soc*, ser. 2, vol. vi., p. 442.

feet of Head consisting of igneous rock and slate fragments irregularly, but often linearly, dispersed in buff-brown sandy soil; in the lower part worn boulders occur at from 3 to 5 feet above the platform. This seems to be a case of admixture of Head and raised beach material.

Formation of the Limestone Plateaux.

Pengelly* drew attention to perforations in the limestones at Petitor at about 235 feet above mean tide; near the northern entrance to Kent's Cavern, and in a small cliff in Asheldon Hill at about 200 feet above mean tide; on the northern slope of Sharkham Point, numerous, in a vertical zone extending from 95 to 165 feet above mean tide; in a small cliff between Brixham and Mudstone Bay slightly more than 200 feet above the sea, but since destroyed by quarry work. He ascribed their production to *Pholas dactylus, P. candida*, and possibly also *P. parva, Saxicava rugosa* and *Venerupis Irus* "whilst the district was undergoing a process of slow upheaval, which was broken by several protracted periods of intermittence." He connects these phenomena with the planing of the limestone plateaux in successive stages as follows—Babbacombe and Daison platform about 280 feet above the sea, Torquay plateaux, 240 feet, Brixham plateau, 200 feet; the two latter being represented by shelves at their respective levels on the flanks of Daison Hill.

Further stages are said to be evidenced by a natural arch in the limestone, probably of marine origin, by the Teignmouth Road between Torre and Upton, at base 176 feet above mean tide; by the planed surface of Roundham head at 75 feet above the sea; and by the raised beach platform at about 30 feet. The Petitor perforations are said to be coeval with the Torquay platforms, those of Kent's Cavern anterior to the introduction of the extinct cave fauna.

As direct evidences of Cretaceous and Eocene denudations are not forthcoming in the area under consideration, the further discussion of this interesting problem would necessarily introduce extraneous evidence.

Submerged Forests.

The traces of submerged vegetation on the shores of Torbay have been long known.† Leland quaintly observes:—"Fisschar men hath divers tymes taken up with theyr Nettes yn Torrebay Musons of hartes, whereby men judge that yn times paste it hath been forest grounde." Godwin-Austen‡ mentions the submerged forest traces of Tor Abbey and Broadsands lying on lacustrine mud, in which at Broadsands *Paludina* shells were obtained; he also notes the occurrence of traces of lacustrine marl at Goodrington beach. Pengelly**noted that in some parts

* *Trans Devon. Assoc.* for 1866. † Leland's *Itin.* vol. iii. p. 545.
‡ "*Geology, S. E. Devon*" p. 439. ** *Trans. Devon. Assoc.* for 1865, p. 30.

of Tor Abbey sands the vegetable matter is 10 feet in thickness. "In this and in the similar deposits of Goodrington and Broadsands bones of *Cervus elaphus, Sus scrofa, Equus caballus, Bos longifrons* and *Elephas primigenius* were found." "Considerable accumulations of vegetable matter with stumps and roots of trees firmly fixed in bluish clay, and evidently the remains of a forest which once grew on the spot, exist in all the inlets of Torbay." The molar of mammoth, considered to have come from submerged forest peat, was dredged in a trawl at about 5 fathoms on the southern side of Torbay. A part of a jaw of *Bos longifrons* was obtained by Pengelly from the Torre Abbey peat between high and low water. During the progress of the Geological Survey the peat with trunks and roots of trees and the blue clay associated with it was well exposed in the Tor Abbey Sands. In the flat now occupied by the Torquay Recreation Ground a thickness of 14 feet of peat upon New Red rock was disclosed in drainage operations; veins of sand were observable in the peat in places. Detached antlers and bones of *Cervus elaphus* were found in peat under red clay, lead coloured at base and from 1 to 1½ feet thick. At about 2 feet down in the peat there was a vein of fine red sand. Pengelly traced the Tor Abbey peat to about 40 feet above mean tide level, in a narrow tongue in the valley west of Torre Station. Under Preston Sands the occurrence of peat and blue clay has been proved.* Peat underlies the alluvium of the Paignton marshes between Torbay Cottage and Roundham Place, also the alluvium bordering Goodrington Sands, and that near Elbury House on the south of Broadsands. A low mound of blown sand fringes the seaward side of the Paignton alluvium.

Pengelly† described a submerged forest at Blackpool Sands which is very rarely exposed; he saw brownish drab-coloured clay crowded with small twigs, leaves, nuts, etc., and numerous prostrate trunks and branches of trees partly embedded in the clay. "Several large stumps projected above the clay in a vertical direction, and sent roots and rootlets into the soil." Mr. Hunt,‡ from a visit paid to the spot during a subsequent exposure, concluded that there are "at least two different deposits of vegetable *débris*."

River Gravels.

The outlet of the Hollicombe Lake stream, near the Torquay Gasworks, is well shown by gravels upon the New Red rocks forming the low cliffs. The cliffs have evidently been cut back since the deposition of the gravel. Fig. 17 represents a part of it.

The terrace gravels of the Dart north of Totnes are, as a rule, well marked by feature. They rise from a few feet, to over 30 feet, above the adjacent alluvium.

The river terrace at Staverton rises from about 15 feet above the alluvium to 30 feet above it. Coarse gravel of worn stones

* Pengelly, *Trans. Devon. Assoc.*, vol. x., p. 201. 1878, Hunt. *Ibid.* for 1881.
† *Ibid.* for 1869, p. 127.
‡ *Ibid.* for 1881, p. 341.

is exposed on its southern margin east of Staverton. The terrace on the east side of Dartington Park is well marked; its breadth decreases southward, and, like the Staverton terrace, its margin is separated from the alluvium by a low bank o Devonian rocks.

The terraces at Totnes Station, Hampstead, between the Dart and the Hems (the Little Hempston stream), and near Springville House rise gently upward from the alluvium.

By the Rifle Range, south-east of Totnes, the alluvium of the Dart is bordered by a river terrace making a bank about 12 feet in height. In this a gravel pit disclosed the following section:—

Buff soil.

Red and brown loam with volcanic stones, sometimes in distinct beds.

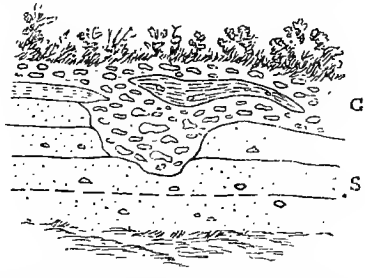
A band of purple on brown loam with very few stones.

Brown loam with volcanic stones and large unworn fragments of diabase, and some worn fragments, perhaps from the underlying gravel.

Gravel of fine dark grey slaty rock, granite, etc., well worn, in a matrix of small worn fragments. The gravel varies from one to three feet in thickness; the lie of the stones denotes current bedding in places, and a lenticular bed of coarse sand is shown at its base in one place. It rests irregularly on slaty volcanic rocks, exposed just above the alluvium, and up to a few feet above it.

The deposits overlying the gravel vary from six to twelve feet in thickness

FIG. 17.—CLIFF SOUTH OF LIVERMEAD.



G. Gravel of flat angular and sub-angular grit stones with small pieces of quartz (one flint pebble was obtained), with a lenticular patch of red clay containing a few stones and a strip of red loam. The base of the gravel is from 5 to 15 feet above high water mark.

S. Reddish brown sand rock containing occasional stones (Lower New Red).

CHANGES IN THE COAST.

White, in his "History of Torquay,"* tells us:—"Within the recollection of persons living, there were cottages and gardens outside the sea wall which bounds the road at Livermead House; and less than fifty years ago there was a grand sandstone arch at Corbon Head which vied in picturesque beauty with the more durable limestone arch on the other side of the bight, locally known as London Bridge. It is worthy of observation that the Torbay Road is at least the third defence which has been raised against the encroachments of the sea. The wall built by Mr. Cary was partially destroyed in 1884; and previously to the erection of that, the original wall was much further out."

* Pp. 159. 160, "Torquay." Printed at the *Directory* Office, 1878.

From the traces of New Red rocks mentioned in this Memoir, and from the presence of outliers, to the south, on the Slapton shore, and near Thurlestone (in sheets 355, 356), there is reason to think that the present coast-line was not far off the position of an old coast-line during the Lower New Red sandstone epoch, and that this circumstance has something to do with the configuration of the present coast, and therefore with the formation of Torbay and the more rapid waste of its inner shores.

CHAPTER VIII.

ECONOMICS.

Water Supply.

The water supply of the villages is from wells. Prior to 1858 Torquay was supplied from wells or private waterworks connected with a reservoir at Ellacombe. In 1856 the waterworks by which the town is now supplied were begun, and completed in 1858. The supply is obtained by impounding streams on the Dartmoor granite near Hennock, about 16 miles from Torquay. Owing to the elevation of the reservoir, the pressure being too great to allow of direct delivery from the mains, two reservoirs, one on Chapel Hill, the other on Warberry Hill, were constructed. The storage Reservoir (Tottiford) on Dartmoor forms a lake covering more than 35 acres, and is said to contain 60,000,000 gallons. The water is soft, having only 2° of hardness according to Shapter,* 0.61 (Clarke's) according to White. The latter gives an analysis by Mr. E. Smith, F.C.S., published in 1873. Referring to water derived from springs at Torre and near the summit of Braddons Hill, Torquay, Shapter, says:—"The waters conveyed from the above sources through iron pipes are clear and sparkling, strongly impregnated with lime, and containing some little iron; their temperature at the fountain head is about 52°.

Dartmouth, Brixham, and Totnes are supplied from local sources and wells.

Borings, Well Sections, etc.

It is much to be regretted that records of the strata passed through in ordinary well sinkings are not kept, and verbal information obtained on that head is never sufficiently clear to be of much scientific value. An Artesian well boring made by the Diamond Rock Boring Company on the premises of the Torquay Brewery, 34 Fleet Street, was begun on February 3, 1875, and abandoned at a depth of 638 feet 7 inches on November 5 of the same year. The following is the section as given in "White's Directory":—

	ft.	in.	
Varieties of Petitor marble, with beds of "Grey Harry" (Beds from 3 to 6 ft. in thickness)	93	0	329 8
Dark liver-coloured limestone, with quartz veins, shillety	236	8	
Plain limestone, varying colours of blue, pink, chocolate and liver coloured.			
Hiatus filled with tenaceous red mud	4	0	
Blue clay slates	82	9	246 4
Chocolate grey slate	65	7	
Second bed of blue clay slate	98	0	
Indurated marl, few cores obtainable	58	7	
	638	7	

* See White's "History of Torquay," pp. 204–211, and Shapter's "Climate of the South-east of Devon," London, 1842.

Mr. H. B. Woodward published the following account in 1877 :*

	ft.	in.
Petitor marble, about	92	0
Plain limestone „	247	8
(Hiatus of two or three feet filled with soft tenaceous red clay.)		
Blue slate	82	9
Chocolate slate	65	7
Blue slate	98	0
Indurated red marl	42	7

The shillety reference, in White's account, denotes a band or lenticle of slate or slaty limestone, of which the thickness is not given. The "Hiatus" is most probably a fault filled with claycy fault rock. The three slate horizons below are presumably Middle Devonian slates, and the indurated marl last encountered would appear to be the upper part of the Lower Devonian. Mr. H. B. Woodward gives the depth of the boring as 628 feet 7 inches, the total depth in limestone as 339 feet 9 inches. He adds: "The inclination (or 'natural cleavage,' as it was termed) of the limestones was about 70°, whereas the inclination of the slates was no more than 45°; and this difference, I am inclined to think, is due to a fault. Owing to this inclination the thickness of the beds passed through may be estimated as follows: Limestone 130 feet, slates 185 feet, red marl 25 feet. Concerning the so-called 'indurated red marl,' I saw a specimen which seemed to belong to one of the junction beds between the slates and red sandstones."

Since the failure of this attempt, White says that the Brewery Company have tapped a spring "rising in the old red sandstone formation, where it is thrown up by the rock of limestone on which the Castle College stands," and obtain their supply through pipes by gravitation.†

At the Lion Brewery, High Street, Totnes, an ineffectual boring for water made by Messrs. Isler & Co., 2 feet dug; 145 feet 4 inch boring, gave the following section :

	ft.	in.
Made ground and soil, etc.	21	0
Shaly rock	3	0
Blue limestone rock	2	6
Blue slate rock	139	6

At Lower Weston Farm, east of Totnes, a well said to have been sunk to a depth of 160 feet seems, from the material thrown out to have been sunk in nearly identical strata with the above, dark blue slates in the upper part of which thin beds of fossiliferous limestone (Eifelian) occur.

In all well sections the thickness of slates penetrated, even where dip of schistosity is given, can scarcely be estimated without ascertaining the true bedding.

The Torquay main sewer commences at a few yards in front of the Spanish Barn, whence it passes across the meadows and

* *Geol. Mag.* for October, 1877.
† "History of Torquay," p. 293.

through the grounds of the Belgrave Hotel, skirting the back of Abbey Crescent, where it joins the first tunnel under Waldon Hill. From this tunnel the sewage passes to the pumping station in Swan Street, where it is raised to a higher level sewer and proceeds through a tunnel from Fleet Street, under Higher Terrace, Apsley House, and Meadfoot Hill, to the sea road, along which it is carried by a barrel sewer and enters the third tunnel under Kilmorie, being finally discharged into the sea at Hope's Nose, a distance of three miles from Torre Abbey. The third tunnel proved the greatest obstacle, "owing to the extreme hardness of the rock, and the depth of working from the surface, and the large quantity of water which flowed in from the springs." The details procurable are, however, of very little value as far as the geology is concerned. One of the shafts was sunk by Middle Woodfield Road, near its junction with Meadfoot Road, through 104 feet of slates to calcareous beds. From Mill Lane to Torre Abbey the excavation was through peat to solid rock; from Belgrave Road to the foot of Waldon Hill partly tunnelled through sandstone easily excavated; between Babbacombe Road and the junction of Meadfoot and Hesketh Roads, the greater part of the tunnel was in limestone rock.* Taking the last-mentioned observation in conjunction with the thickness of slate penetrated in Middle Woodfield Road, it would appear that the slates are either above the limestone, or inverted for part of the distance between Babbacombe Road and Hesketh Crescent.

Mines, Quarries, etc.

The following notes are chiefly compiled from White's "History of Torquay," † Collins' "Mineralogy of Cornwall and Devon," ‡ a paper by R. N. Worth on "The Economic Geology of Devon," § and a paper by E. T. Appleton ‖ on "The Economic Geology of Devon."

Mines and Manufactures.—About the year 1680, the then Earl of Londonderry erected stamping mills, etc., at great cost in the brook near Westhill and that running by the Teignmouth Road, in the vain hope of finding tin lodes. In a lease dated 1720 mines between Torwood and Hope's Nose are mentioned. As late as 1850 an iron mine was worked at Torre, between the Infirmary and the first house in Higher Union Street on the hillside facing Upton, but in a few years the operations were abandoned. Rich samples of iron ore were raised in another part of Torquay about ten years later. Collins gives the following list of mines in 1871, worked for hematite and limonite:—Torquay, the Torbay Mine. Paignton, Gympton (Galmpton ?). Brixham, Five Acre, Prosper Huel, Parkins and Sharpham (Sharkham ?). Worth tells us that "Mr. Wolston, of Brixham, started a paint manufactory in connection with

* See Chatterton on "Torquay Drainage."
† Torquay, 1878. ‡ Truro: Heard & Sons, 1871.
§ *Trans. Devon. Assoc.* for 1875, pp. 209–233. ‖ *Ibid.* pp. 234–246.

his iron mines, in which the softer parts of the ore were made into ochreous pigments, and similar paints are still manufactured there." Brick and tile works have been opened in dark red brown clunchy clay belonging to the Watcombe clay series, but the clay from which the terra cotta is made is worked in the map to the north of sheet 350, although the same horizon occurs near Torre. Lime for manure or mortar has been afforded by the limestones nearly everywhere, but for hydraulic cement the only mention of suitable limestone is by Appleton, *viz.*; the small patch on the borders of the volcanic series at Harbertonford, although there are, no doubt, many patches of Eifelian limestones of the same character, and the admixture of shale with the Middle Devonian limestones would doubtless afford suitable material for the purpose.

Mineral Waters.—Worth mentions a chalybeate spring at Totnes, not, however, used medicinally.

Building Materials.

The limestones of Torquay and Brixham, etc., are extensively quarried for building stone. The more massive limestone rocks are used for sea walls, etc., often in association with large blocks of New Red conglomerate or breccia, which is also quarried for building purposes at Chelston and Paignton. The hard sandstones of the Waddeton and Brixham outliers, are mentioned by Appleton as being considered by workmen harder to dress than granite. The massive limestones of Ipplepen, Petitor, etc., when polished, form ornamental marble used chiefly in interior church architecture. Worth says: "The Ipplepen marble is chiefly characterised by a roseate dove-colour ground with reddish veins." The Torquay marbles vary much in colour and appearance, some being very distinctly coralline. Lapidaries have special names for the fossiliferous limestones; thus limestone full of *Favosites cervicornis*, such as that at Saltern Cove, is called "Featherstone." The Lower Devonian grits are locally used for building material, as also the slates where their planes are closely compacted. The volcanic rocks are either too hard or too soft to be largely used for building purposes.

Roofing Slate.—Slate has been quarried near Nethway House, south of Brixham, and in many parts of the slate district, for purely local purposes. The slate quarries of Harbertonford are just outside the limits of the map, on the west.

Road Metal.

The harder aphanites and diabases are largely used for road stone. Appleton says that "greenstone near Greenway, on the Dart, has long been used for the metropolitan roads," and in the "Report on the Building Stones of the United Kingdom" for the year 1858, by R. Hunt, trap rock at Dartmouth and metamorphic rock at Sandquay, near Dartmouth, are said to have been used for the same purpose. The Sandquay rock is a hard igneous rock.

The Devonian limestones are largely used for road metal, but for that purpose are inferior to the carboniferous limestone.

Soils.

The volcanic rocks afford the richest soil in the district. The plum orchards at Dittisham are grown on this soil. The New Red rocks also afford rich soil suitable either for grazing or tillage, and varying, according to their constitution, from comparatively light loamy or sandy soil to comparatively heavy clayey land. The Lower Devonian rocks also produce variable soils according to the local prevalence of grits or of slates. In the slate areas of the Upper, Middle, and Lower Devonian the more clayey and heavier soils are naturally most often encountered. The limestone soils are for the most part thin and clayey, and consequently much affected in seasons of drought.

The celebrated orchards of Staverton grow on the soil of Eifelian slates, partly covered by river terrace *débris*.

APPENDIX.

List of the Principal Works on the Geology of the District.

1829. De la Beche, [Sir] H. T. On the Geology of Tor and Babbacombe Bays, Devon. *Trans. Geol. Soc.*, ser. 2, vol. iii., part i., p. 161.

1839. De la Beche, [Sir] H. T. Report on the Geology of Cornwall. Devon, and West Somerset. (*Geological Survey*). 8vo. London, (Index by C. Reid, 1903.)

1840. Sedgwick, Rev. A. and [Sir] R. I. Murchison. On the Physical Structure of Devonshire, and on the Subdivisions and Geological Relations of its Older Stratified Deposits, &c. *Trans. Geol. Soc.*, ser. 2, vol. v., part iii., p. 633.

Lonsdale, W. Notes on the Age of the Limestone of South Devonshire. *Trans. Geol. Soc.*, ser. 2, vol. v., part iii., p. 721.

1841. Phillips, Prof. J. Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset (*Geological Survey.*) 8vo. London.

1842. [Godwin-] Austen, R.A.C. On the Geology of the South-East of Devonshire. *Trans. Geol. Soc.*, ser. 2, vol. vi., part ii. (This includes the substance of papers printed in abstract in *Proc. Geol. Soc.* in 1834, 1836, 1839 and 1840).

Shapter, Dr. T. The Climate of the South of Devon and its Influence on Health. 8vo. London. (2nd Edition, 1862).

1846. De la Beche, Sir H. T. On the formation of the Rocks of South Wales and South-Western England. *Mem. Geol. Survey*, vol. i. (Many references to this district and to literature will be found in pp. 65-95 and p. 105).

1847. Vivian, E. Extract of a letter from Mr. E. Vivian of Torquay, respecting the Phenomena of Kent's Cavern. *Rep. Brit. Assoc. Trans. of Sects.*, 1847, p. 73.

1857. Pengelly, W. On the Beekites found in the Red Conglomerates of Torbay. *Rep. Brit. Assoc. Trans. of Sects.*, p. 74. In full in *Trans. Roy. Geol. Soc. Cornwall*, vol. vii., p. 309.

Vivian, E. Researches in Kent's Cavern, with the original MS. Memoir of its first opening, by the late Rev. J. MacEnery. *Rep. Brit. Assoc. Trans. of Sects.*, 1856, p. 79.

—— The earliest traces of human Remains in Kent's Cavern. *Ibid.*, 1856, p. 119.

1859. McEnery, Rev. J. Cavern Researches. Edited by E. Vivian. 4to. London.

1861. Pengelly, W. On a New Bone Cave at Brixham. (Brit. Assoc.) *Geologist*, vol. iv., pp. 153, 456.

1862. PENGELLY, W.
The Geographical and Chronological Distribution of the Devonian Fossils of Devon and Cornwall. (Brit. Assoc.)
Geologist, vol. iv., pp. 10, 74.
—— Letter on Accumulation of Cave Deposits. *Ibid.*, p. 65.

1862, 3, 5, ——The Red Sandstones and Conglomerates of Devonshire.
Trans. Plymouth Institute, Parts i., ii., iii.

1864, 5. DAVIDSON, T. A., Monograph of the British Devonian Brachiopoda. Parts i. and ii. *Palæontographical Soc.*, 4to, London.
SALTER, J. W. A Monograph of British Trilobites. Parts i. and ii. *Ibid.*

1865. PENGELLY, W. On the Beekites found in the Red Conglomerate at Torbay. *Trans. Roy. Geol. Soc. Cornwall*, vol. vii., p. 309.
—— Raised Beaches of Torbay. *Trans. Devon. Assoc.*, vol. i., p. 33.

1866. PENGELLY, W. Report on the Exploration of Kent's Cavern.
Proc. Roy. Inst., iv., p. 534.
—— On the Lithodomus perforations above the sea level in the Limestone Rocks in South-east Devonshire.
Trans. Devon. Assoc., vol. i., p. 82.
—— On Certain Joints and Dykes in the Devonian Limestones on the Southern Shore of Torbay. *Geol. Mag.*, vol. iii., p. 19.

1868. PENGELLY, W. History of the discovery of Fossil Fish in the Devonian Rocks of Devon and Cornwall.
Trans. Devon. Assoc, vol. ii., part 2, p. 423.
HOLL, Dr. H. B. On the Older Rocks of South Devon and East Cornwall. *Quart. Journ. Geol. Soc.*, vol. xxiv., p. 400.

1869. PENGELLY, W. On a Submerged Forest at Blackpool, near Dartmouth, South Devon. *Trans. Devon. Assoc.*, vol. iii., p. 127.

1870. TAWNEY, E. B. On the occurrence of Fossils at Smuggler's Cove, Torquay. *Ibid.*, vol. iv., p. 291.

1873. CHAMPERNOWNE, A. On the discovery of a Species of Starfish in Devonian Beds of S. Devon. *Rep. Brit. Assoc.* xliii., p. 77.
PENGELLY, W. Anstis Cove Cavern.
Trans. Devon. Assoc., vol. vi., p. 61.
PRESTWICH, [Sir] J. Report on the Exploration of Brixham Cavern.
Phil. Trans., vol. clxiii., pp. 471–572.

1874. CHAMPERNOWNE, A. On a Contortion of the Limestone at Torquay and the presence of *Calceola sandalina* at its base.
Trans. Devon. Assoc., vol. vi., p. 548.
PENGELLY, W. The Cave Discovered in 1858 in Windmill Hill, Brixham, South Devon. *Ibid.*, pp. 775–856.

875. APPLETON, E. On the Economic Geology of Devon.
Ibid., vol. vii., p. 234.
WORTH, R. N. Economic Geology of Devon. *Ibid.*, vol. vii., p. 209.

1876. USSHER, W. A. E. On some Old Gravels of the River Dart between Totnes and Holne Bridge. *Ibid.*, vol. viii.
On the Triassic Rocks *of* Somerset and Devon.
Quart. Journ. Geol. Soc., vol. xxxii., p. 367.

1877. LEE, J. E. Notice of the Discovery of Upper Devonian Fossils in the Shales of Torbay. *Geol. Mag.*, Dec. 2, vol. iv., 1877, p. 100.

1877. USSHER, W. A. E. On the Age and Origin of the Watcombe Clay. *Trans. Devon. Assoc.*, vol. ix., p. 296. (*See also* Appleton, E., *Trans. Devon. Assoc.*, for 1865, p. 66.)

WOODWARD, H. B. Notes on the Devonian Rocks near Newton Abbot and Torquay; with remarks on the subject of their classification. *Geol. Mag.*, Dec. 2, vol. iv., p. 447.

1878. CHAMPERNOWNE, A. Notes on the Devonians and Old Red Sandstone of North and South Devon. *Geol. Mag.*, Dec. 2, vol. v., p. 193.

HUNT, A. R. Notes on Torbay. *Trans. Devon. Assoc.*, vol. ix., p. 400.

PENGELLY, W. The Geology of the North-Eastern Coast of Paignton. *Trans. Devon. Assoc.*, vol. x., p. 196.

—— Fourteenth Report of the Committee for Exploring Kent's Cavern, Devonshire. *Rep. Brit. Assoc.*, p. 124.

USSHER, W. A. E. On the Geology of Paignton. *Trans. Devon. Assoc.*, vol. x., p. 203.

On the Chronological value of the Triassic Strata of the South-western Counties. *Quart. Journ. Geol. Soc.*, vol. xxxiv. p. 467.

——The Chronological Value of the Pleistocene Deposits of Devon. *Ibid.* p. 449.

White's History of Torquay. Printed at the *Directory* Office, Torquay.

1879. CHAMPERNOWNE, A. Notes on some Devonian Stromatoporidæ from Dartington, near Totnes. *Quart. Journ. Geol. Soc.*, vol. xxxv., p. 67.

1880. ROEMER, Dr. F. Notice of the Occurrence of Upper Devonian Goniatite Limestone in Devonshire. *Geol. Mag.*, vol. vii., p. 145.

1881. CHAMPERNOWNE, A. Notes on a Find of *Homalonotus* in Red Bed. at Torquay. *Geol. Mag.*, vol. viii, p. 487.

HUNT, A. R. On Exposures of the Submerged Forest Clays at Paignton and Blackpool Beaches in April, 1881. *Trans. Devon. Assoc.*, vol. xiii., p. 344.

1882. DAVIDSON, T. Supplement to the British Devonian Brachiopoda. *Palæontographical Soc.*, pp. 4, 8.

PENGELLY, W. Notes on Recent Notices of the Geology and Palæontology of Devonshire. *Trans. Devon. Assoc.*, vol. xiv., p. 637.

1884. CHAMPERNOWNE, A. On some Zaphrentoid Corals from British Devonian Beds. *Quart. Journ. Geol. Soc.*, vol. xl., p. 497.

1885. —— *Homalonotus crassicaudata* from S. Devon. *Geol. Mag.*, Dec. 3, vol. ii., p. 285.

PIDGEON, D. On Some Recent Discoveries in the Submerged Forest of Torbay. *Quart. Journ. Geol. Soc.*, vol. xli., p. 9.

1886. PENGELLY, W. Happaway Cavern. *Trans. Devon. Assoc.*, vol. xviii., p. 225.

1887. WOODWARD, H. B. Geology of England and Wales, 2nd ed. pp. 130-139.

1888. HUNT, A. R. The Raised Beach on the Thatcher Rock: its Shells and their Teaching. *Trans. Devon. Assoc.*, vol. xx., p. 225.

JONES, Prof. T. R. On some New Devonian Ostracoda. *Ann. Mag. Nat. Hist.*, p. 299.

1889. Champernowne, A. On the Ashprington Volcanic Series.
Quart. Journ. Geol. Soc., vol. xlv., p. 369.

Kayser, Dr. E. Ueber das Devon in Devonshire und im Boulonnais. *Neües Jahrbuch f. Mineralogie*, bd., i., p. 179.

1889. Sandberger, Prof. Dr. F. v. Über die Entwickelung der unteren Abtheilung des Devonischen Systems in Nassau.
Jahrb. d. Nass. Ver. f. Nat. Jahrg. 42.

Ussher, W. A. E. The Devonian Rocks of Great Britain.
Rep. Brit. Assoc., p. 179.
The Triassic and Devonian Rocks of West Somerset. [*See* general classification of Devonian rocks.]
Proc. Somerset Arch. and Nat. Hist. Soc., vol. xxxv.

1889-95. Whidborne, Rev. G. F. A Monograph of the Devonian Fauna of the South of England. *Palæontographical Soc.*, vols. i. and ii.

1890. Jones, Prof. T. R. On some Devonian Entomides.
Ann. Mag. Nat. Hist. p. 317.

Ussher, W. A. E. The Devonian Rocks of South Devon.
Quart. Journ. Geol. Soc., vol. xlvi., p. 487.

1892. Prestwich, Sir J. The Raised Beaches and Head, or Rubble Drift, of the South of England; their Relation to the Valley Drifts and to the Glacial Period; and on a Late Post-Glacial Submergence. *Quart. Journ. Geol. Soc.*, vol. xlviii., p. 263.

Wethered, E. On the Microscopic Structures and Residues Insoluble in Hydrochloric Acid in the Devonian Limestones of South Devon. *Ibid*, p. 377.

1893. Busz, Dr. K. Referring to Igneous Rocks, Babbacombe Bay.
Sitz. d. Niederreinische Gesell. im Bonn, p. 85.

1898. Hunt, A. R. A Short Account of Kent's Cavern. (*Torquay Nat. Hist. Soc.*) 8vo. Torquay, pp. 11. Privately printed.

1900. Ussher, W. A. E. The Devonian, Carboniferous, and New Red Rocks of West Somerset, Devon, and Cornwall.
Proc. Somerset Arch. and Nat. Hist. Soc., vol. xlvi.

Woodward, H. B., A. R. Hunt, and W. A. E. Ussher. Excursion to Newton Abbot, Chudleigh, Dartmoor, and Torquay.
(With plan of Kent's Cavern).
Proc. Geol. Assoc. vol. xvi., pp. 425–442.

1901. Whidborne, Rev. G. F. Devonian Fossils from Devonshire, Part 2. Lower Devonian Fossils from Torquay.
Geol. Mag. Dec. 4, vol. viii. p. 533.

INDEX.

GENERAL MEMOIRS.

[illegible]CAL SURVEY for 1897, 1898, 1899, 1900, 1901, and 1902. Each 1*s*.

PLIOCENE DEPOSITS of BRITAIN. By C. REID. 5*s*. 6*d*.

CRETACEOUS ROCKS OF BRITAIN.—Vol. I. GAULT AND UPPER GREENSAND OF ENGLAND. 9*s*. Vol. II. LOWER AND MIDDLE CHALK. By A. J. JUKES-BROWNE and W. HILL.

JURASSIC ROCKS OF BRITAIN.—Vol. I. YORKSHIRE, 8*s*. 6*d*. Vol. II. YORKSHIRE, Fossils, 12*s*. By C. FOX-STRANGWAYS. Vol. III. LIAS OF ENGLAND (Yorkshire excepted). 7*s*. 6*d*. By H. B. WOODWARD. Vol. IV. The Lower Oolitic Rocks of England. 10*s*. By H. B. WOODWARD. Vol. V. The Middle and Upper Oolitic Rocks of England. 7*s*. 6*d*. By H. B. WOODWARD.

BRITISH ORGANIC REMAINS. DECADES I. to XIII., with 10 Plates each. Price 4*s*. 6*d*. each 4to; 2*s*. 6*d*. each 8vo.

MONOGRAPH I. On the Genus PTERYGOTUS. By T. H. HUXLEY and J. W. SALTER. 7*s*.

MONOGRAPH II. On the Structure of the BELEMNITIDÆ. By T. H. HUXLEY. 2*s*. 6*d*.

MONOGRAPH III. On the CROCODILIAN REMAINS found in the ELGIN SANDSTONES. By T. H. HUXLEY. 14*s*. 6*d*.

MONOGRAPH IV. On the CHIMÆROID FISHES of the British Cretaceous Rocks. By E. T. NEWTON. 5*s*.

VERTEBRATA of the PLIOCENE DEPOSITS of BRITAIN. By E. T. NEWTON. 4*s*.

Museum, Catalogues, &c. :—

HANDBOOK to the MUSEUM of PRACTICAL GEOLOGY. 6*d*.

FOSSILS:—CAMBRIAN and SILURIAN, 2*s*. 6*d*.; CRETACEOUS, 2*s*. 9*d*.; TERTIARY and POST-TERTIARY, 1*s*. 8*d*.

DISTRICT MEMOIRS.

MEMOIRS of the GEOLOGICAL SURVEY OF GREAT BRITAIN. Vol. I. ESSAYS by DE LA BECHE and Others. 21*s*. Vol. II. Part 1, MALVERN HILLS. By J. PHILLIPS. 21*s*. Part 2, ESSAYS. 21*s*. Vol. III. N. WALES. By SIR A. C. RAMSAY. App., by J. W. SALTER and R. ETHERIDGE. 2nd Ed. 21*s*.

CAMBRIDGE. By W. H. PENNING and A. J. JUKES-BROWNE. 4*s*. 6*d*.

CORNWALL, DEVON, AND WEST SOMERSET. INDEX to DE LA BECHE'S Report on. By C. REID. 1*s*.

DERBYSHIRE, NORTH. By A. H. GREEN, C. LE NEVE FOSTER and J. B. DAKYNS. 2nd Ed. By A. H. GREEN and A. STRAHAN. 5*s*. 6*d*.

FENLAND By S. B. J. SKERTCHLY. 36*s*. 6*d*.

HOLDERNESS. By C. REID. 4*s*.

ISLE OF MAN. By G. W. LAMPLUGH. 12*s*.

TERTIARY FLUVIO-MARINE FORMATION of the ISLE OF WIGHT. By EDWARD FORBES. 5*s*.

ISLE OF WIGHT. By H. W. BRISTOW. New Ed. By C. REID and A. STRAHAN. 8*s*. 6*d*.

ISLE OF PURBECK AND WEYMOUTH. By A. STRAHAN. 10*s*. 6*d*.

LAKE DISTRICT, NORTHERN PART OF. By J. C. WARD. 9*s*.

LANCASHIRE, SUPERFICIAL DEPOSITS OF SOUTH WEST. By C. E. DE RANCE. 10*s*. 6*d*.

LONDON AND PART OF THE THAMES VALLEY. By W. WHITAKER. Vol. I., 6*s*. Vol. II., 5*s*.

MIDLAND COUNTIES, TRIASSIC and PERMIAN ROCKS of the. By E. HULL. 5*s*.

NORFOLK and SUFFOLK, VERTEBRATA of the FOREST RED SERIES of. By E. T. NEWTON. 7*s*. 6*d*.

NORWICH. By H. B. WOODWARD. 7*s*.

RUTLAND, &c. By J. W. JUDD. 12*s*. 6*d*.

WEALD (PARTS of KENT, SURREY, SUSSEX, and HANTS). By W. TOPLEY. 17*s*. 6*d*.

Eruptive Rocks :—

ERUPTIVE ROCKS of BRENT TOR. By F. RUTLEY. 15*s*. 6*d*.

FELSITIC LAVAS of ENGLAND and WALES. By F. RUTLEY. 9*d*.

Iron Ores of Great Britain :—

Part II. South Staffordshire. Price 1*s*. Part III. South Wales. Price 1*s*. 3*d*. Part IV The Shropshire Coal. field and North Staffordshire. 1*s*. 3*d*.

Coal Fields :—

BURNLEY COALFIELD. By E. HULL, R. H. TIDDEMAN [and Others]. 12*s*.

YORKSHIRE COALFIELD. By A. H. GREEN, R. RUSSELL [and Others]. 42*s*.

EAST SOMERSET and BRISTOL COALFIELDS. By H. B. WOODWARD. 18*s*.

WARWICKSHIRE COALFIELD. By H. H. HOWELL. 1*s*. 6*d*.

LEICESTERSHIRE COALFIELD. By EDWARD HULL. 3*s*.

SOUTH WALES. (See under Sheet Memoirs, New Series).

Sanitation and Water Supply :—

SOILS AND SUBSOILS from a SANITARY POINT of VIEW. By H. B. WOODWARD. 2*s*. 6*d*

WATER SUPPLY OF SUSSEX. By W. WHITAKER and C. REID. 3*s*.

WATER SUPPLY OF BERKSHIRE, By J. H. BLAKE and W. WHITAKER. 3*s*.

Gun Flints :—

MANUFACTURE OF GUN FLINTS. By S. B. J. SKERTCHLY. 16*s*.

SHEET MEMOIRS OF OLD SERIES MAPS.

London Sheet. Guide to the GEOLOGY of LONDON and NEIGHBOURHOOD. By W. WHITAKER. 6th Ed. 1*s*.

4 - - - FOLKESTONE and RYE. By F. DREW. 1*s*.

34 - - PARTS of WILTS, and GLOUCESTERSHIRE. By A. C. RAMSAY, W. T. AVELINE, and E. HULL. 8*d*.

44 - - - CHELTENHAM. By E. HULL. 2*s*. 6*d*.

45 - - - BANBURY, WOODSTOCK, and BUCKINGHAM. By A. H. GREEN. 2*s*.

45 SW - - WOODSTOCK. By E. HULL. 1*s*.

47 - - - N.W. ESSEX & N.E. HERTS. By W. WHITAKER, W. H. PENNING, W. H. DALTON, & F. J. BENNETT. 3*s*. 6*d*.

48 SW - COLCHESTER By W. H. DALTON. 1*s*. 6*d*.

48 SE - - EASTERN END of ESSEX (WALTON NAZE and HARWICH). By W. WHITAKER. 9*d*.

48 NW, NE - IPSWICH, HADLEIGH, and FELIXSTOWE. By W. WHITAKER, W. H. DALTON, & F. J. BENNETT. 2*s*.

49 S, 50 SE - ALDBOROUGH, &c. By W. H. DALTON. Edited, with additions, by W. WHITAKER. 1*s*.

49 N - - SOUTHWOLD By W. WHITAKER. 2*s*. 6*d*.

50 SW - - STOWMARKET. By W. WHITAKER, F. J. BENNETT and J. H. BLAKE. 1*s*.

SHEET MEMOIRS OF

50 NW - DISS, EYE, &c. By F. J. BENNETT. 2s.
50 NE - HALESWORTH and HARLESTON. By W. WHITAKER and W. H. DALTON. 1s.
51 SE - BURY ST. EDMUNDS and NEWMARKET. By F. J. BENNETT, J. H. BLAKE, and W. WHITAKER. 1s.
51 NE - PARTS of CAMBRIDGESHIRE and SUFFOLK. By W. WHITAKER [and Others]. 2s.
53 SE - PART of NORTHAMPTONSHIRE. By W. T. AVELINE and RICHARD TRENCH. 8d.
53 NE - PARTS of NORTHAMPTONSHIRE and WARWICKSHIRE. By W. T. AVELINE. 8d.
65 - S.W. NORFOLK and N. CAMBRIDGESHIRE. By W. WHITAKER, S. B. J. SKERTCHLY, and A. J. JUKES-BROWNE. 3s.
66 SW - ATTLEBOROUGH. By F. J. BENNETT. 1s. 6d.
67 NW - E. DEREHAM. By. J. H. BLAKE. 1s. 6d.
67 - YARMOUTH and LOWESTOFT. By J. H. BLAKE. 2s.
68 E - CROMER. By C. REID. 6s.
68 NW, SW - FAKENHAM, WELLS, &c. By H. B. WOODWARD. 2s.
69 - BORDERS OF THE WASH. By W. WHITAKER, and A. J. JUKES-BROWNE. 3s.
70 - S. W. LINCOLNSHIRE, &c. By A. J. JUKES-BROWNE, and W. H. DALTON. 4s.
71 NE - NOTTINGHAM. By W. T. AVELINE. (2nd Ed.) 1s.
79 NW - RHYL, ABERGELE, and COLWYN. By A. STRAHAN. (Notes by R. H. TIDDEMAN). 1s. 6d.
79 SE - FLINT, MOLD, and RUTHIN. By A. STRAHAN. (Parts by C. E. De RANCE). 4s. 6d.; *Supplement* 2d.
80 NW - PRESCOT, LANCASHIRE. By E. HULL. (3rd Ed. With additions by A. STRAHAN.) 3s.
80 SW - CHESTER. By A. STRAHAN. 2s.
81 NW, SW - STOCKPORT, MACCLESFIELD, CONGLETON, and LEEK. By E. HULL and A. H. GREEN. 4s.
82 SE - PARTS of NOTTINGHAMSHIRE and DERBYSHIRE. By W. T. AVELINE. (2nd Ed.) 6d.
82 NE - PARTS of NOTTINGHAMSHIRE, YORKSHIRE, and DERBYSHIRE. (2nd Ed.) By W. T. AVELINE. 1s.
83 - - LINCOLN. By W. A. E. USSHER, A. J. JUKES-BROWNE, and A. STRAHAN. 3s.
84 - - EAST LINCOLNSHIRE. By A. J. JUKES-BROWNE. 3s. 6d.
86 - N. LINCOLNSHIRE and S. YORKSHIRE. By W. A. E. USSHER [and Others]. 2s.
87 NW - WAKEFIELD and PONTEFRACT. By A. H. GREEN. 6d.
87 SW - BARNSLEY. By A. H. GREEN. 9d.
88 SW - OLDHAM. By E. HULL. 2s.
88 SE - PART of the YORKSHIRE COALFIELD. By A. H. GREEN, J. R. DAKYNS, and J. C. WARD. 1s.
88 NE - DEWSBURY, &c. By A. H. GREEN, J. R. DAKYNS, J. C. WARD, and R. RUSSELL. 6d.
89 SE - BOLTON, LANCASHIRE. By E. HULL. 2s.
90 SE - COUNTRY between LIVERPOOL and SOUTHPORT. By C. E. DE RANCE. 3d.
90 NE - SOUTHPORT, LYTHAM, and SOUTH SHORE. By C. E. DE RANCE. 6d.
91 SW - COUNTRY between BLACKPOOL and FLEETWOOD. By C. E. DE RANCE. 6d.
91 NW - SOUTHERN PART of the FURNESS DISTRICT in N. LANCASHIRE. By W. T. AVELINE. 6d.
92 SE - BRADFORD and SKIPTON. By J. R. DAKYNS, C. FOX-STRANGWAYS, R. RUSSELL, and W. H. DALTON. 6d.
93 NW - NORTH and EAST of HARROGATE. By C. FOX-STRANGWAYS. 6d.
93 NE - COUNTRY between YORK and MALTON. By C. FOX-STRANGWAYS. 1s. 6d.
93 NW - N. and E. of LEEDS and near TADCASTER. By W. T. AVELINE, A. H. GREEN (and Others).
93 SE, 94 W - COUNTRY between YORK and HULL. By J. R. DAKYNS, C. FOX-STRANGWAYS, and A. G. CAMERON. 1s.
94 NW - DRIFFIELD. By J. R. DAKYNS and C. FOX-STRANGWAYS. 9d.
94 NE - BRIDLINGTON BAY. By J. R. DAKYNS and C. FOX-STRANGWAYS. 1s.
95 SW, SE - SCARBOROUGH and FLAMBOROUGH HEAD. By C. FOX-STANGWAYS. 1s.
95 NW - WHITBY and SCARBOROUGH. By C. FOX-STRANGWAYS and G. BARROW. 1s. 6d.
96 SE - NEW MALTON, PICKERING, and HELMSLEY. By C. FOX-STRANGWAYS. 1s.
96 NE - ESKDALE, ROSEDALE, &c. By C. FOX-STRANGWAYS, C. REID, and G. BARROW. 1s. 6d.
96 NW, SW - NORTHALLERTON and THIRSK. By C. FOX-STRANGWAYS, A. G. CAMERON, and G. BARROW. 1s. 6d.
97 SW - INGLEBOROUGH. By J. R. DAKYNS, R. H. TIDDEMAN, W. GUNN, and A. STRAHAN. 2s.
97 NW - MALLERSTANG. By J. R. DAKYNS, R. H. TIDDEMAN (and Others). 3s. 6d.
98 SE - KIRKBY LONSDALE and KENDAL. By W. T. AVELINE, T. MC K. HUGHES, and R. H. TIDDEMAN. 2s.
98 NE - KENDAL. By W. T. AVELINE and T. MC K. HUGHES. 2nd Ed. by A. STRAHAN. 2s.
102 SW - APPLEBY, ULLSWATER, and HAWESWATER. By J. R. DAKYNS, R. H. TIDDEMAN, and J. G. GOODCHILD. 1s. 6d.
104 SW, SE - NORTH CLEVELAND. By G. BARROW. 1s. 6d.
107 - CARLISLE. By T. V. HOLMES. 1s. 3d.
108 SE - OTTERBURN and ELSDON. By HUGH MILLER. 2s. 6d.
108 NE - CHEVIOT HILLS. By C. T. CLOUGH. 1s. 6d.
108 SW - FLASHETTS and KIELDER. By C. T. CLOUGH 1s.
110 SW - WOOLER and COLDSTREAM. By W. GUNN and C. T. CLOUGH. 1s. 6d.
110 NW - NORHAM and TWEEDMOUTH. By W. GUNN. 6d.
110 NE - COAST SOUTH of BERWICK-ON-TWEED. By W. GUNN.
110 SE - BELFORD, HOLY ID, and FARNE ISLANDS. By W GUNN. 2s. 6d.

SHEET MEMOIRS OF NEW SERIES MAPS.

123 - STOKE-UPON-TRENT. By W. GIBSON and C. B. WEDD. Price 1s. 6d.
155 - ATHERSTONE and CHARNWOOD FOREST. By C. FOX-STRANGWAYS. 2s.
156 - LEICESTER. By C. FOX-STRANGWAYS. 3s.
232 - ABERGAVENNY. By A. STRAHAN and W. GIBSON. 2s.
248 - PONTYPRIDD. By A. STRAHAN, R. H. TIDDEMAN, and W. GIBSON. 1s. 6d.
249 - NEWPORT, MON. By A. STRAHAN. 2s.
263 - CARDIFF. By A. STRAHAN and T. C. CANTRILL. 2s. 3d.
268 - READING. By J. H. BLAKE and H. W. MONOKTON. 1s. 6d.
298 - SALISBURY. By C. REID (and Others). 1s. 3d.
314 - RINGWOOD. By C. REID (and Others). 1s.
315 - SOUTHAMPTON. By C. REID. 1s. 6d.
325 - EXETER. By W. A. E. USSHER. 2s.
328 - DORCHESTER. By C. REID. 1s.
329 - BOURNEMOUTH. By C. REID. 4d.
332 - BOGNOR. By C. REID. 6d.
334 - EASTBOURNE. By C. REID. 6d.